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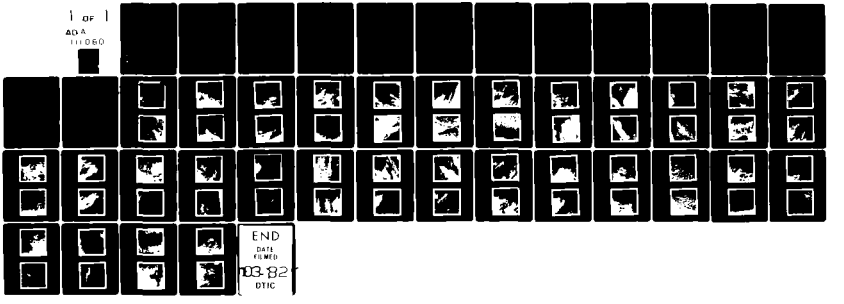

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Satellite Observations in FRONTS 80

Michael L. Van Woert

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Early observations in the Central North Pacific indicate a general decrease in temperature and salinity as one moves northward from the equator. The change is not a smooth function of latitude, but rather, superimposed on a steady poleward decrease of temperature and salinity are regions of abrupt change called fronts (Seckel, 1968; Roden 1972). The general strength and location of the mid-ocean fronts are well-known. Near 45°N latitude is the Pacific Subarctic Front. It separates the . . .

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Satellite Observations in FRONTS 80

by

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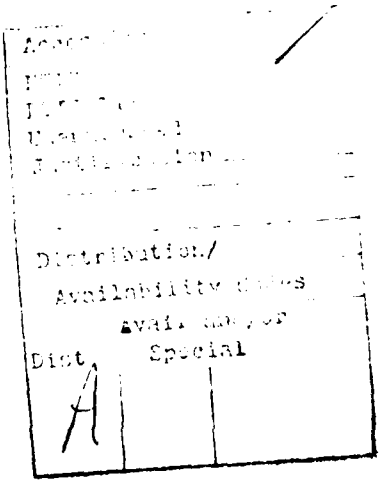
The Regents of University of California

SIO Reference No. 81-38

November 1981



1. INTRODUCTION

Early observations in the Central North Pacific indicate a general decrease in temperature and salinity as one moves northward from the equator. The change is not a smooth function of latitude, but rather, superimposed on a steady poleward decrease of temperature and salinity are regions of abrupt change called fronts (Seckel, 1968; Roden 1972).

The general strength and location of the mid-ocean fronts are well-known. Near 45°N latitude is the Pacific Subarctic Front. It separates the Pacific Subarctic water mass from the North Pacific Central water mass and is characterized by a change of $4°C$ per $30km$ and $0.6‰$ per $30km$ across the front. In the vicinity of 32°N is the Pacific Subtropical Front. It separates the North Pacific Central water mass from the Pacific Equatorial water mass and is characterized by a change of $2°C$ per $30km$ and $0.25‰$ per $30km$ across the front (Roden, 1975). A schematic map of the Central North Pacific Fronts is shown in Fig. 1. Although the general location and strength of the mid-ocean fronts are well documented, little is known about variability associated with frontal strength and position.

In an effort to address this question White et. al. (1978) used historical XBT data to examine the large scale seasonal and secular variability of the North Pacific Subtropical Front. They found the front to be strongest in the Spring and weakest in the Fall. Their work further suggests that on large space and time scales the front is basically a zonal feature which is located furthest north in the Spring and furthest south in the Fall. Observations collected in the Atlantic Ocean on shorter time scales and smaller space scales suggest that mid-ocean fronts are much more complex than suggested by the study of White et. al. (1978).

Voorhis and Hersey (1964) towed instruments across an Atlantic mid-ocean front at various locations in an effort to map the two dimensional structure of the front. They found deformation scale meandering of the front and temperature changes of $1°C$ per $10km$ across the front. Their work further suggests that the along front flow is nearly in geostrophic balance. Subsequent investigations (Katz, 1969; Voorhis, 1969) have essentially confirmed the earlier findings. Although each of these studies provided valuable information on the variability of

mid-ocean fronts, none of the studies attempted to map the full three dimensional space and time structure of a mid-ocean front.

In December 1979 a large observational program (FRONTS 80) was undertaken to obtain basic scale information on a mid-ocean front. The North Pacific Subtropical Front, near 31°N, 153°W was chosen as the experiment site because of its logistical proximity to the U. S. mainland and Hawaii, and because extensive historical data exists for this region.

2. OBSERVATIONS

An important component of the FRONTS 80 experiment was the collection of NOAA-6 Advanced Very High Resolution Radiometer (AVHRR) data. NOAA-6 operates in a near-polar sunsynchronous orbit. It orbits at a height of 850*km* providing global coverage roughly twice daily. The AVHRR has a 1.1-*km* spatial resolution and is a 4 channel device, viewing in the visible (VIS, 0.62μ and 0.91μ) and infrared (IR, 3.7μ and 11.0μ) portions of the spectrum. For the IR channels, the noise equivalent differential temperature (NEDT), which expresses the sensor sensitivity is about 0.1°C when viewing the ocean surface. Thus, the sea surface temperature difference between two 1.1-*km* areas veiwed by the scanner may be resolved if it is larger than the radiometers NEDT. More information on the spacecraft and sensor can be found in Schwalb (1978).

The NOAA-6, AVHRR data for the FRONTS 80 experiment was collected at Hickam AFB, Hawaii and shipped to the Scripps Satellite Oceanography Facility for processing. All of the passes were collected at about 0500Z on days when the satellite passed over the experiment site. In all, 60 passes were collected between 18 December, 1979 and 18 March, 1980. Table 1 lists the dates of satellite coverage. Typical satellite data coverage can be seen in Fig. 2.

Each satellite pass consists of four data channels, the visible channels centered around 0.62μ and 0.91μ, and two infrared channels centered around 0.37μ and 11.0μ. The visible channels were not processed because the data was collected after dark; however, both infrared channels were processed. Only the 3.7μ channel imagery is shown in the figures because ocean

structure is generally easier to detect in the 3.7μ data than it is in the 11.0μ data when atmospheric moisture is present. This is a consequence of the fact that a moist atmosphere is more transparent to 3.7μ radiation than it is to 11.0μ radiation (Selby and McClatchey, 1975).

In addition to the satellite observations two hydrographic surveys were conducted in the vicinity of 31°N, 153°W. The first survey took place during the period 24 January - 30 January, 1980 and the second survey took place between 31 January - 11 February 1980. The horizontal station spacing was about 37*km* and the hydrocasts were to 1500m. Roden (1980) provides a complete description of the hydrographic data and the details of the processing. Many other measurements were made as well. The large scale synoptic temperature field was mapped using Air-expendable bathythermograph data collected from Navy P-3C aircraft. Near surface currents and temperature were obtained from ten Polar Research satellite-tracked drifters deployed in the FRONTS 80 experiment region. Lastly, a whole host of fine structure and microstructure measurements were made during the experiment. A data report has been prepared which describes more completely all the measurements made during the FRONTS 80 field program (Paulson and Niiler, 1980).

3. DATA PROCESSING AND PHOTO INTERPRETATION

a) Data Processing

Extensive processing done in three steps is required to produce the imagery shown in this report. In the first step of processing the raw AVHRR data is extracted from the satellite telemetry data stream. This produces a 720 x 720 array of data with each data value representing the radiance from an area 1.1*km* x 1.1*km*. The earth location of each data point can be determined from a knowledge of the spacecraft orbital elements and time. In order to keep processing time and storage requirements to reasonable limits, row/column indices and latitude/longitude pairs are stored for 200 evenly spaced data points. These 200 position sets are used to construct a two dimensional second degree least squares polynomial relating latitude/longitude to row/column.

The second stage of processing makes corrections to the data array and the earth location file in an effort to remove the effects of earth rotation and curvature. The details of this algorithm can be found in Legeckis and Pritchard (1976).

The third stage of processing is a two dimensional first order least square mapping which maps the output from the Legeckis and Pritchard algorithm to an equal area projection. This step serves merely to rotate and translate the data so that the imagery is centered at 31°N,153°W and has the latitude/longitude grid aligned with the rows and columns. It should be noted in passing that this final stage of processing maps only 512 x 512 data points from the original 720 x 720 array of data. This is necessary because the display device is limited to arrays no larger than 512 x 512. 720 x 720 arrays rather than 512 x 512 arrays were extracted in step one to ensure a complete 512 x 512 array at the completion of step three.

The accuracy of this three stage procedure was checked using coastal data from the Hawaiian Islands. The data containing the Hawaiian Islands was extracted from the passes on 17 January, 1980 (Julian day 017) and 9 February, 1980 (Julian day 040) processed in the manner described above. Coastal points with known latitudes and longitudes were compared with the location calculated from the earth location transformations. The calculated positions for both days deviated from the true location by less than $5km$.

b) Image Interpretation

All the imagery in the figures have been processed as described above. The images are centered at 31°N, 153°W with each tic mark representing 1° of latitude or longitude. In the images clouds are white, cool northern water is light grey, and warm southern water is dark. All the images have been enhanced in such a way that the contrast across thermal boundaries is maximized.

References

Katz, E. J., 1969: Further Study of a Front in the Sargasso Sea. *Tellus*, **XXI(2)**, 259-269.

Legeckis, R. and J. Pritchard, 1976: Algorithm for Correcting The VHRR Imagery for Geometric Distortions due to Earth Curvature, Earth Rotation, and Space Craft Roll Attitude. *NOAA Technical Memorandum NESS 77.*

Paulson, C.A. and P.P. Niiler, 1981: FRONTS 80: Preliminary Results From an Investigation of the Wintertime North Pacific Subtropical Front. *Oregon State Univ. Tech. Report 81-2.*

Roden, G.I., 1972: Temperature and Salinity Fronts at the Boundaries of the Subarctic-Subtropical Transition Zone in the Western Pacific. *J. Geophys. Res.*, **77(36)**, 7175-7187.

Roden, G.I., 1975: On North Pacific Temperature, Salinity, Sound Velocity and Density Fronts and their Relation to the Wind and Energy Flux Fields. *J. Phys. Ocean.*, **5(4)**, 557-571.

Roden, G.I., 1980: FRONTS Expedition CTD Data Report 15 January - 16 February 1980. *University of Washington Tech. Report No. 384.*

Schwalb, A.,1978: The TIROS-N/NOAA A-G Satellite Series. *NOAA Tech. Memo. NESS 95*, 75pp.

Seckel, G.R., 1968: A Time-Sequence Oceanographic Investigation in the North Pacific Trade-Wind Zone. *Trans., American Geophys. Union*, **49(1)**, 377-387.

Selby, J.E.A. and R.A. McClatchey, 1975: Atmospheric Transmittance from 0.25 to 28.5 μm: Computer Code **LOWTRANS 3**, *Cambridge Optical Physics Laboratory of Air Force Cambridge Research Laboratories Report AFCRL-TR-0255.*

Voorhis, A.D. and J.B. Hersey, 1964: Oceanic Thermal Fronts in the Sargasso Sea. *J. Geophys. Res.*, **69(18)**, 3809-3814.

Voorhis, A.D., 1969: The Horizontal Extent and Persistence of Thermal Fronts in the Sargasso Sea. *Deep-Sea Res. Sup.* **16**, 331,337

White, W.B., K. Hasunuma and H. Solomon, 1978: Large-Scale Seasonal and Secular Variability of the Subtropical Front in the Western North Pacific from 1954-1974. *J. Geophys. Res.* **83(C9)**, 4531-4544.

Acknowledgments

Capt. A. Adams and Msgt. C. Henderson, Jr., U.S. Air Force, Air Weather Service, Hickam AFB, Hawaii provided the NOAA-6 data. Robert Whritner helped with the processing in the initial stages of the study. Theodore Young and Joseph Fahle wrote much of the image processing software needed to produce the imagery in this report. Their help is greatly appreciated. Robert Bernstein coordinated the satellite program during FRONTS 80 and invited my parcticipation in the experiment. For this I am indebted.

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Table 1. Dates of Satellite Coverage.

Fig. A		Fig. B		
Date	Julian Day	Date	Julian Day	Page
13 November, 1979	317	12 December, 1979	346	12
18 December, 1979	352	19 December, 1979	353	13
20 December, 1979	354	21 December, 1979	355	14
22 December, 1979	356	23 December, 1979	357	15
24 December, 1979	358	25 December, 1979	359	16
26 December, 1979	360	27 December, 1979	361	17
28 December, 1979	362	29 December, 1979	363	18
30 December, 1979	364	2 January, 1980	002	19
3 January, 1980	003	4 January, 1980	004	20
5 January, 1980	005	6 January, 1980	006	21
8 January, 1980	008	10 January, 1980	010	22
11 January, 1980	011	12 January, 1980	012	23
13 January, 1980	013	14 January, 1980	014	24
15 January, 1980	015	16 January, 1980	016	25
17 January, 1980	017	18 January, 1980	018	26
19 January, 1980	019	20 January, 1980	020	27
21 January, 1980	021	22 January, 1980	022	28
24 January, 1980	024	25 January, 1980	025	29
26 January, 1980	026	27 January, 1980	027	30
28 January, 1980	028	30 January, 1980	030	31
1 February, 1980	032	8 February, 1980	039	32
9 February, 1980	040	13 February, 1980	044	33
14 February, 1980	045	15 February, 1980	046	34
17 February, 1980	048	18 February, 1980	049	35
19 February, 1980	050	20 February, 1980	051	36
22 February, 1980	053	23 February, 1980	054	37
24 February, 1980	055	7 March, 1980	067	38
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14 March, 1980	074	18 March, 1980	078	41

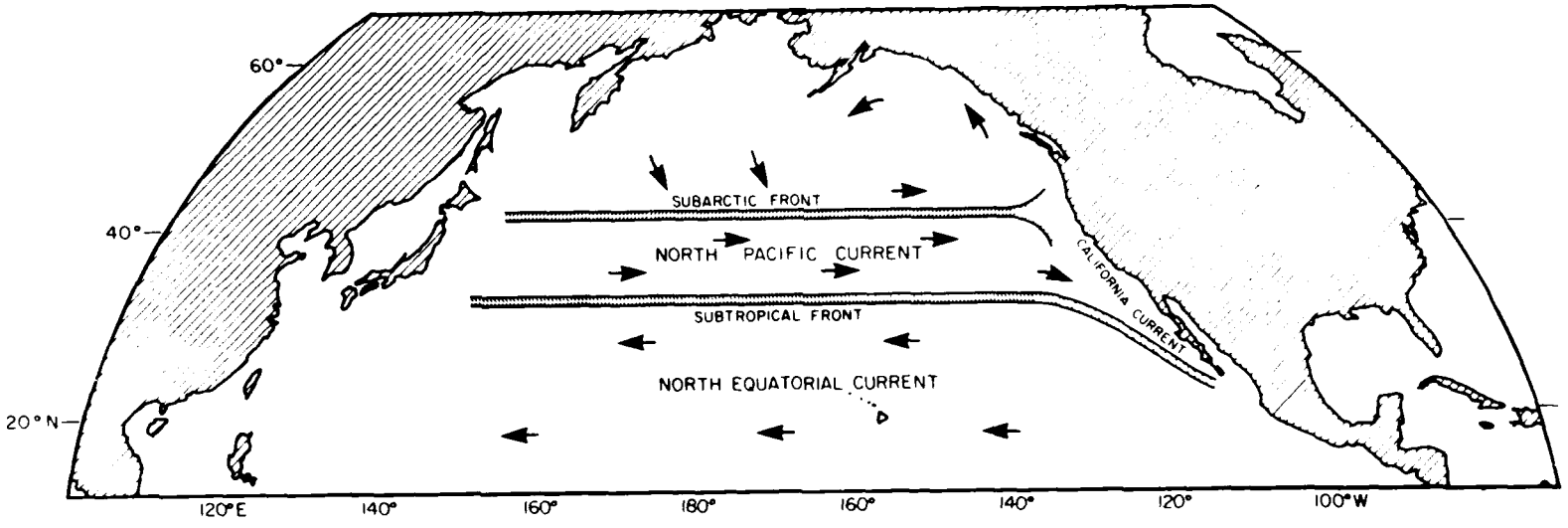
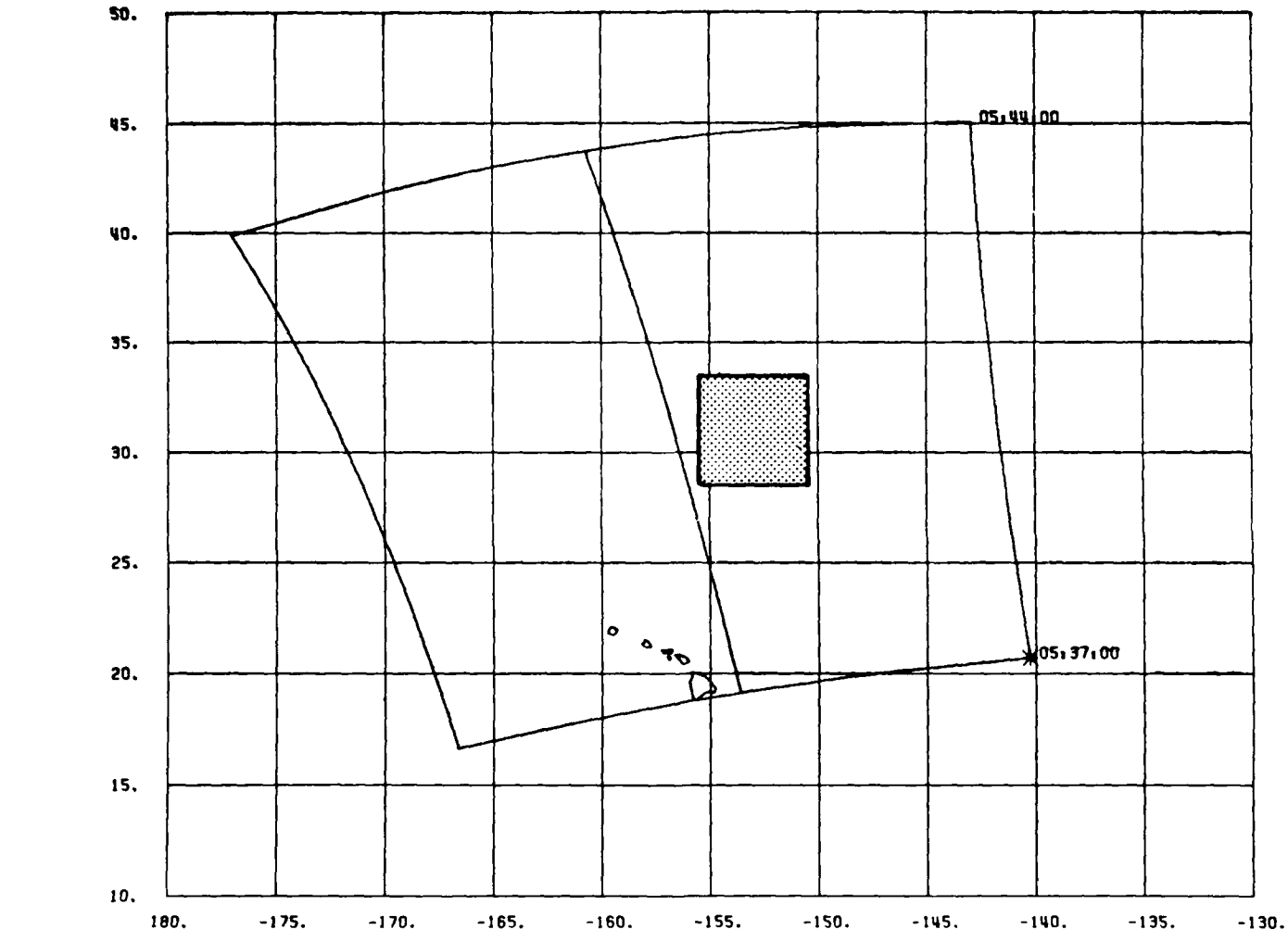


Figure 1. Schematic diagram of North Pacific mid-latitude fronts.



SATELLITE:NOAA6 SENSOR:AVHRR
START TIME: 40 2/ 9/80 5:37: 0
STOP TIME: 40 2/ 9/80 5:44: 0
PROJECTION:EQUIRECTANGULAR SASF

Figure 2. Typical NOAA-6 data coverage. The stipled area represents the region covered by the satellite data contained in this report.

NOAA-6 SATELLITE DATA:

FRONTS 80

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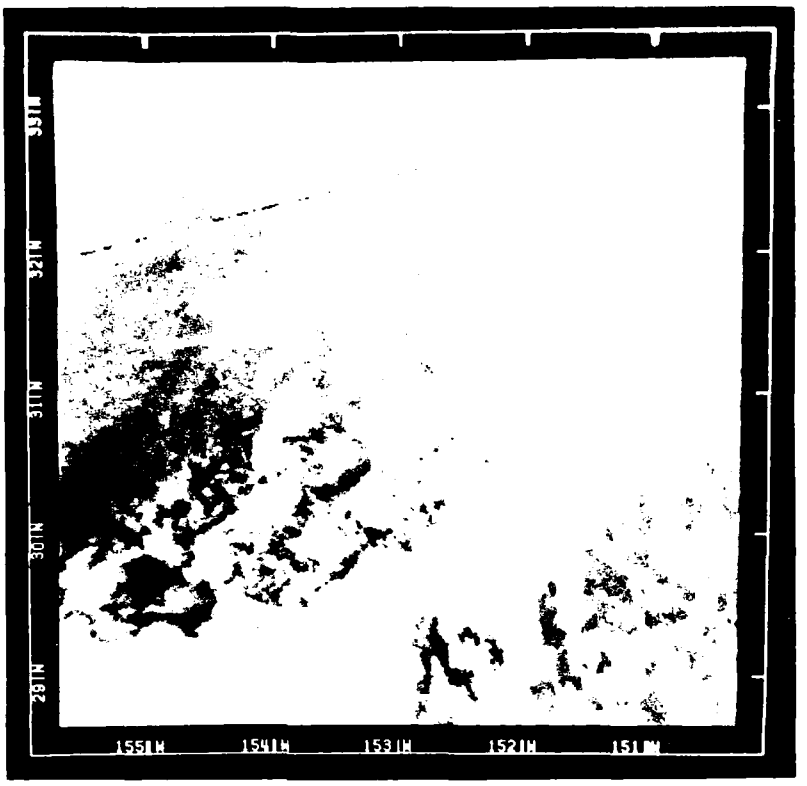

13 November, 1979 JD 317

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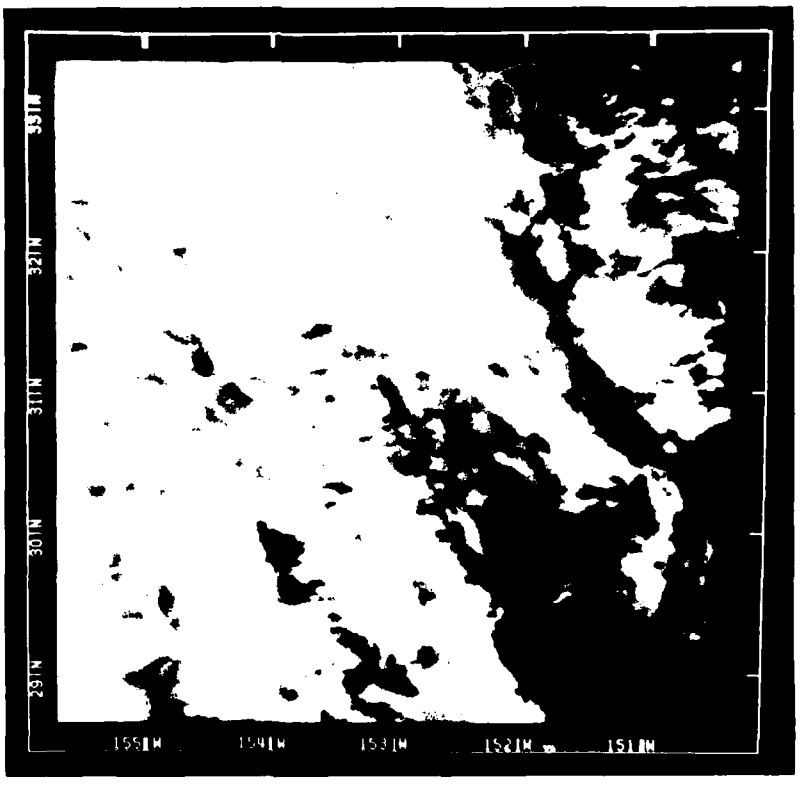

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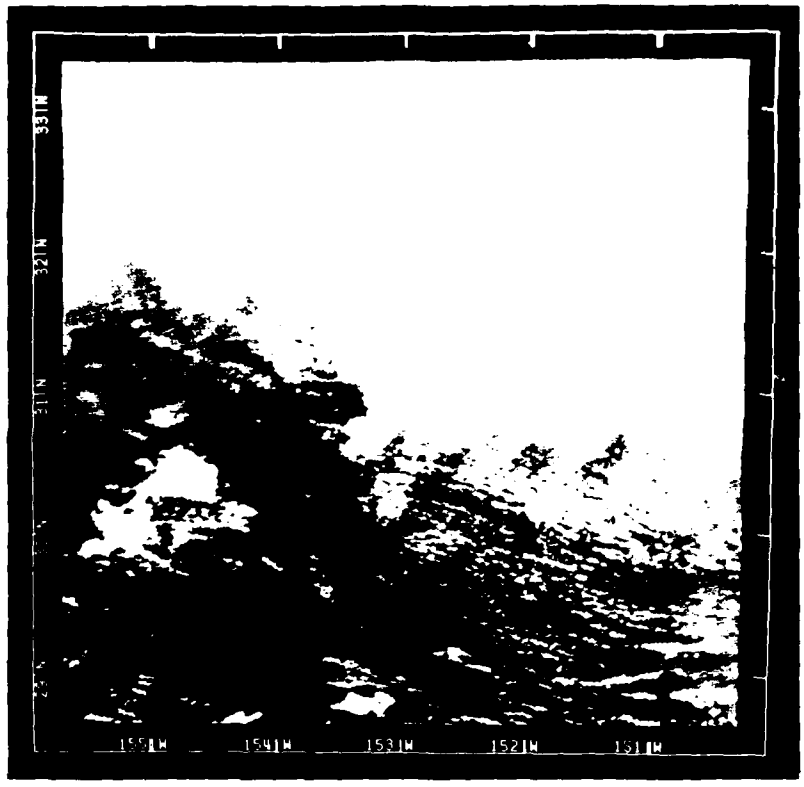

18 December, 1979 JD 352

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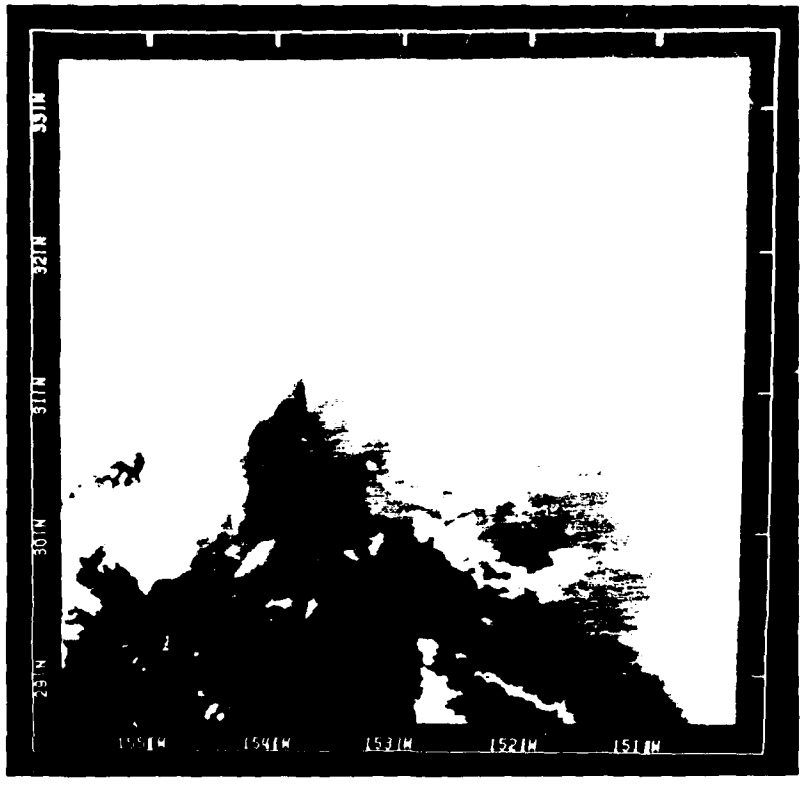

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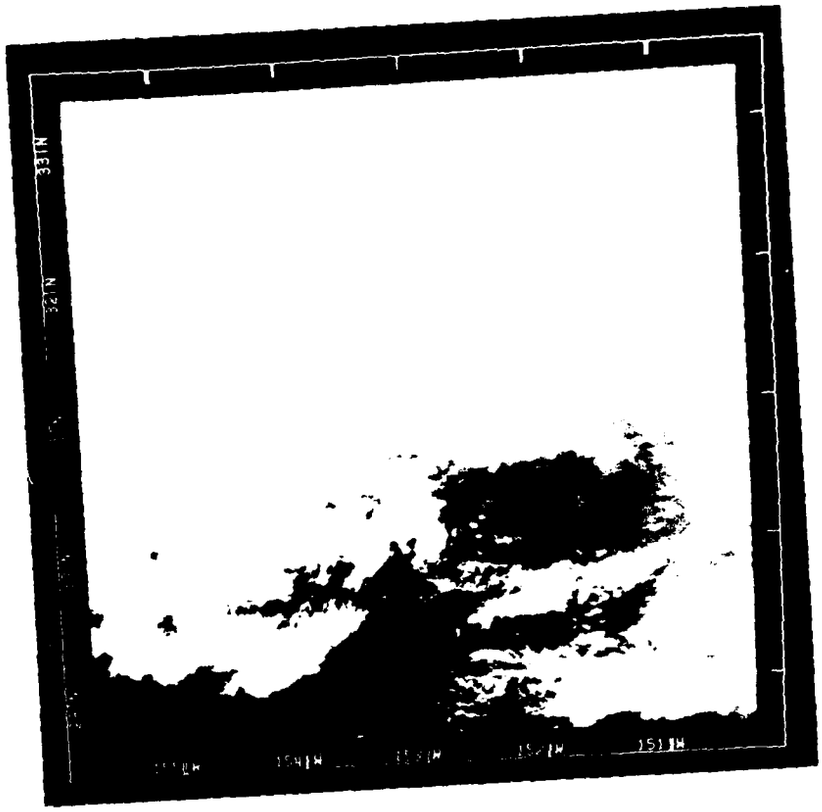

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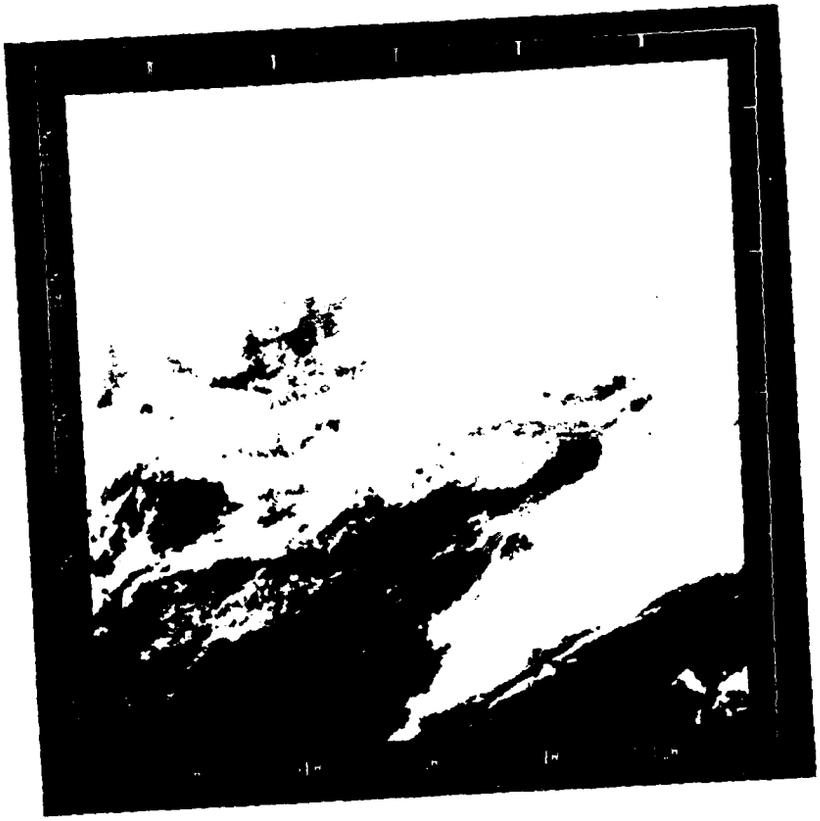

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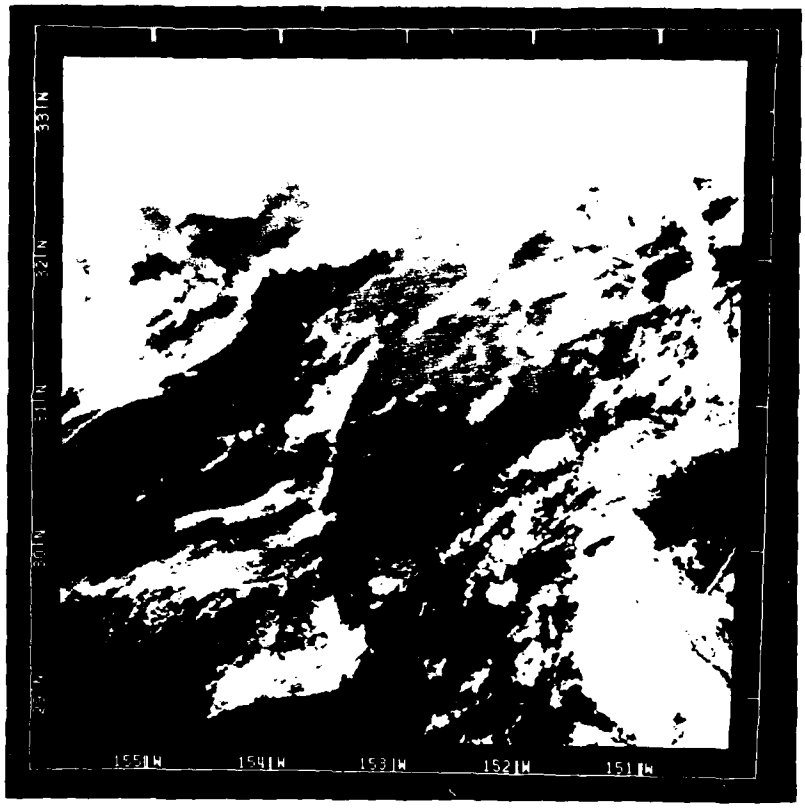

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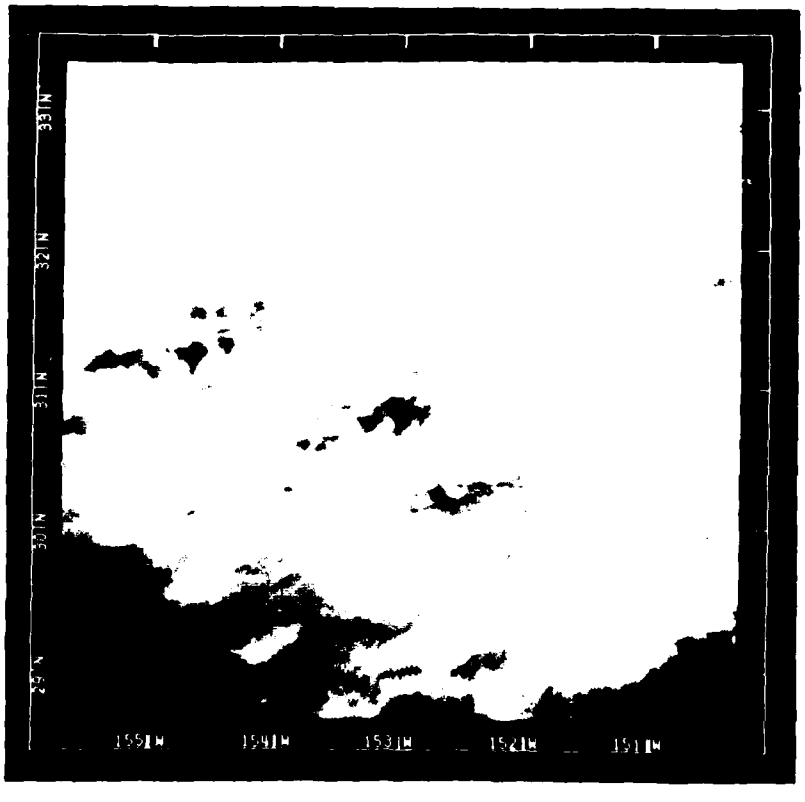

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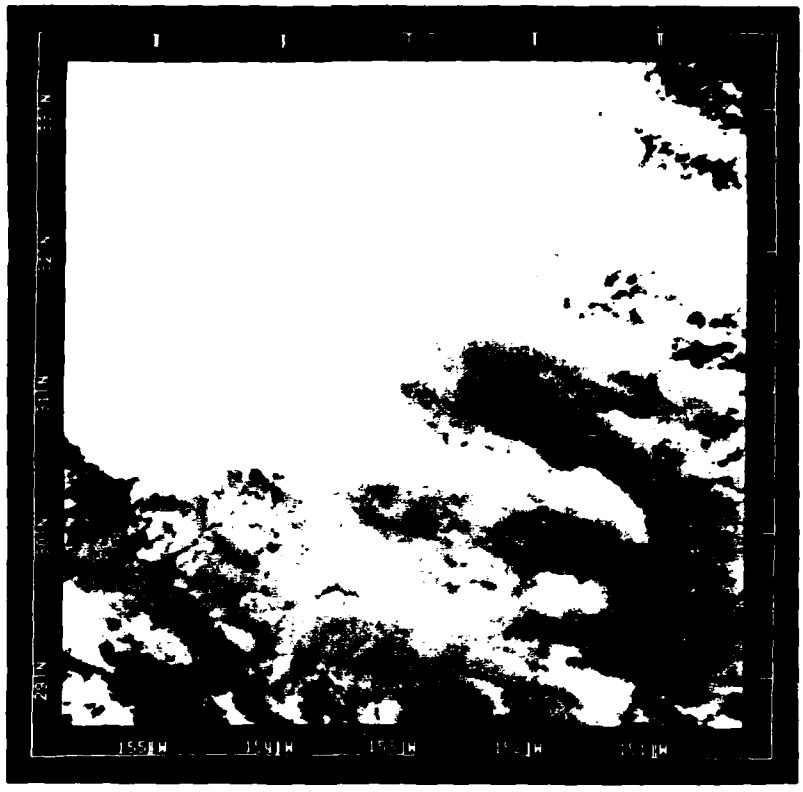

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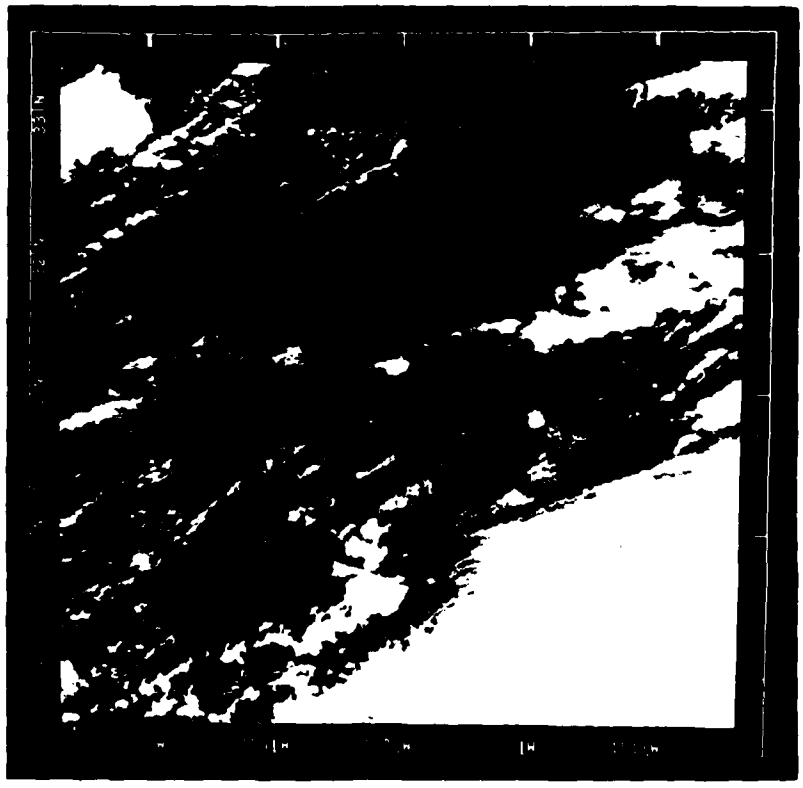

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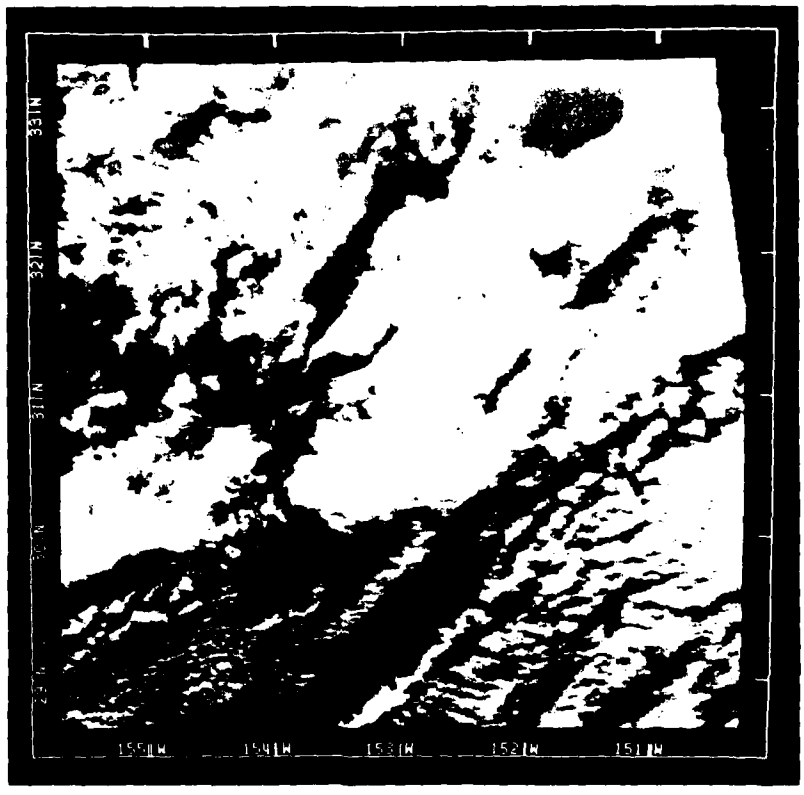

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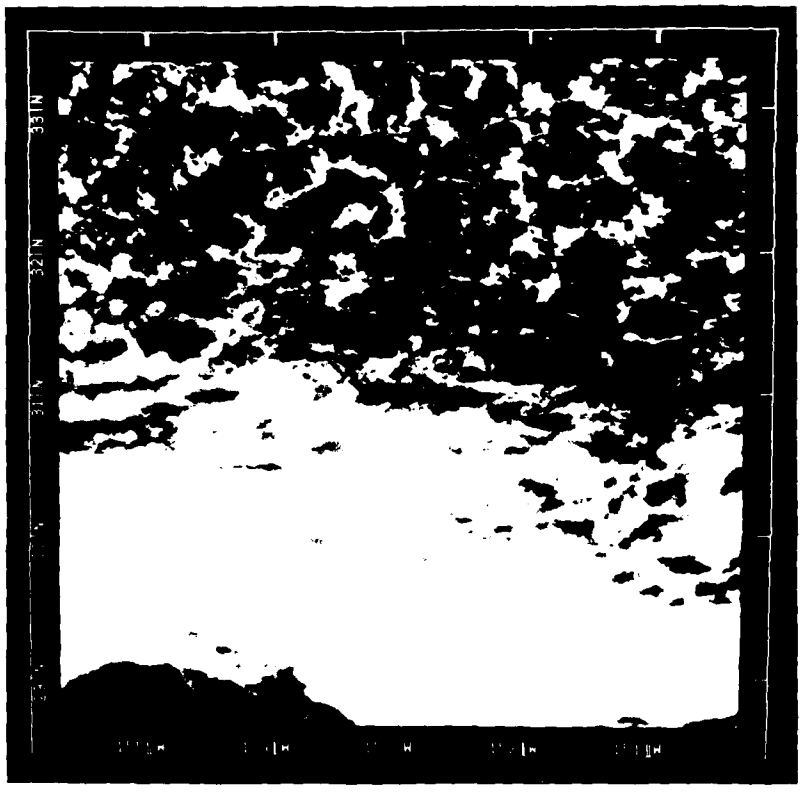

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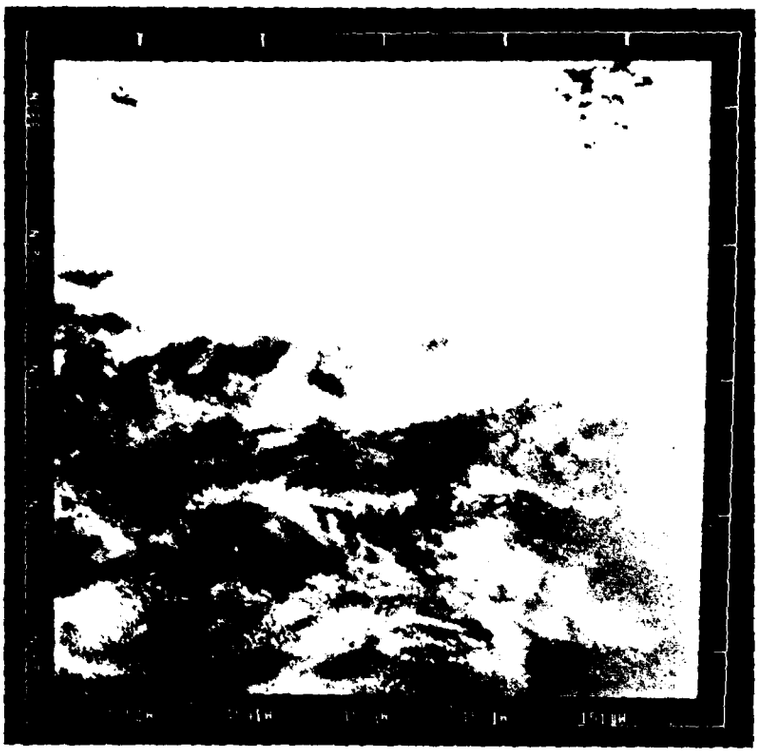

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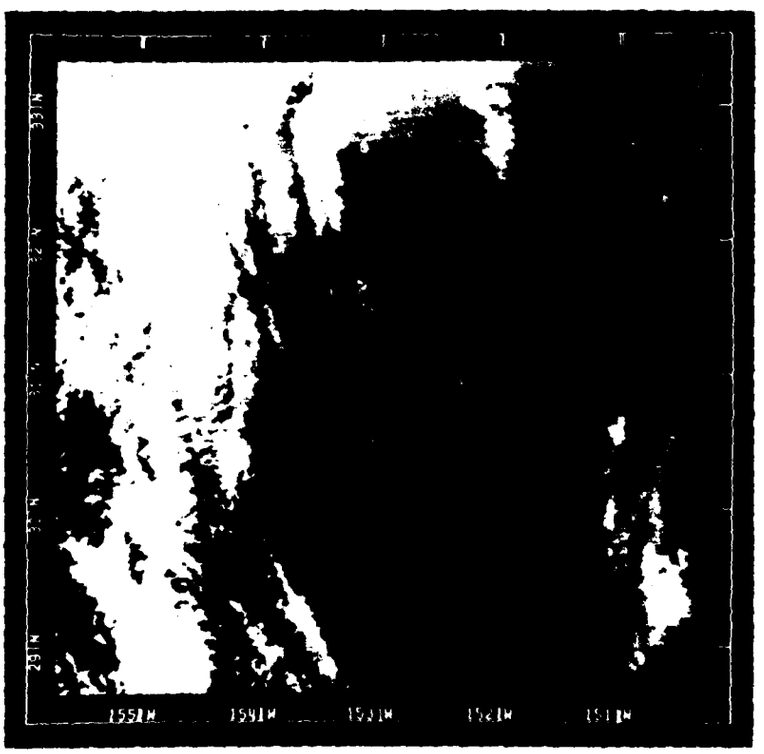

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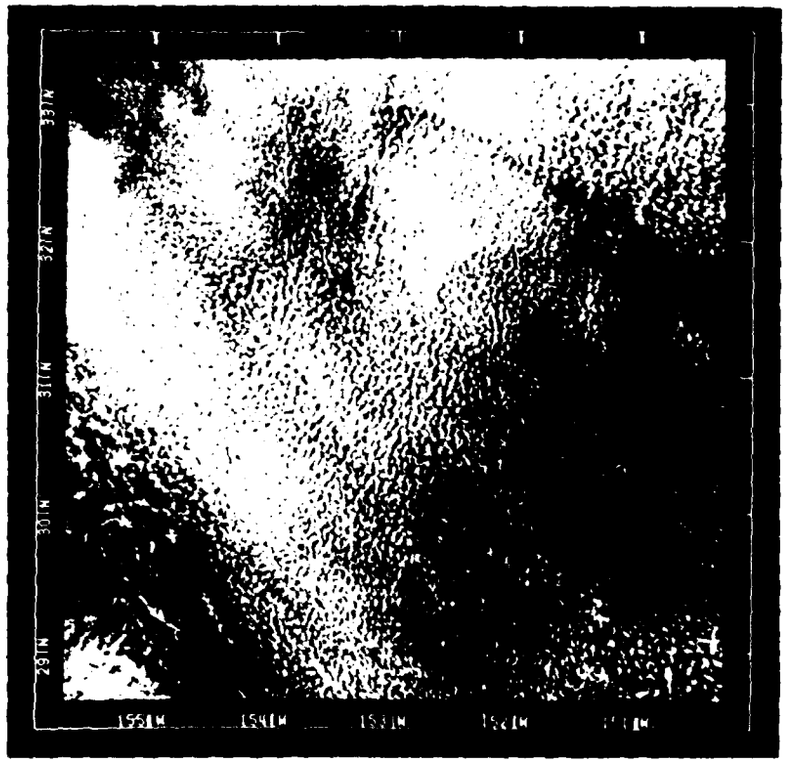

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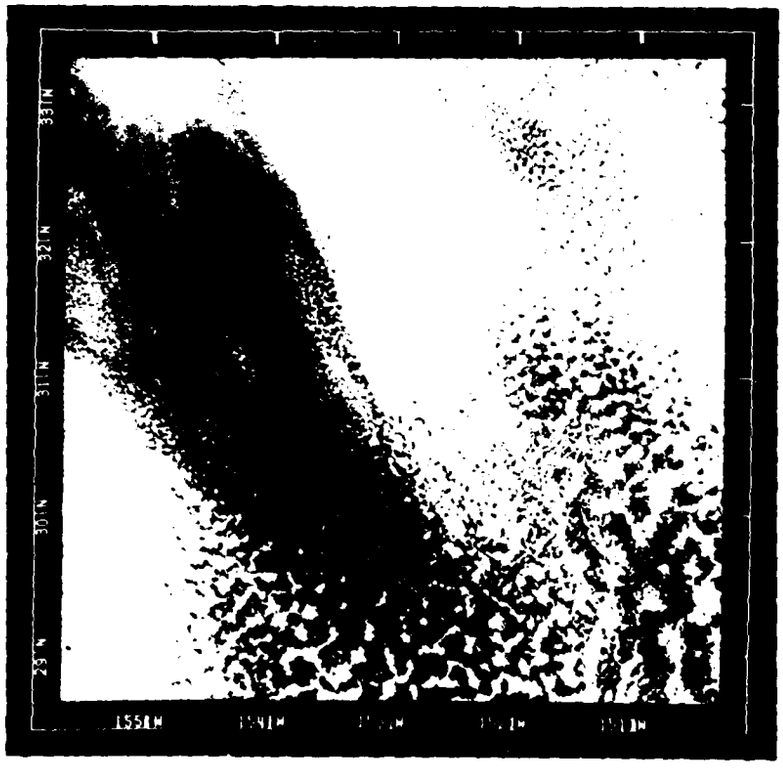

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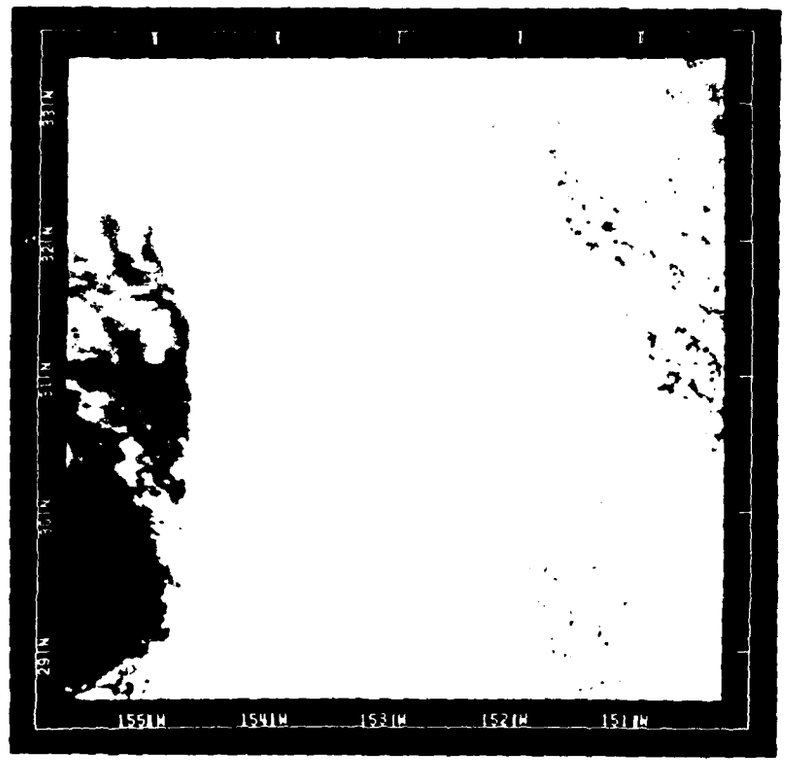

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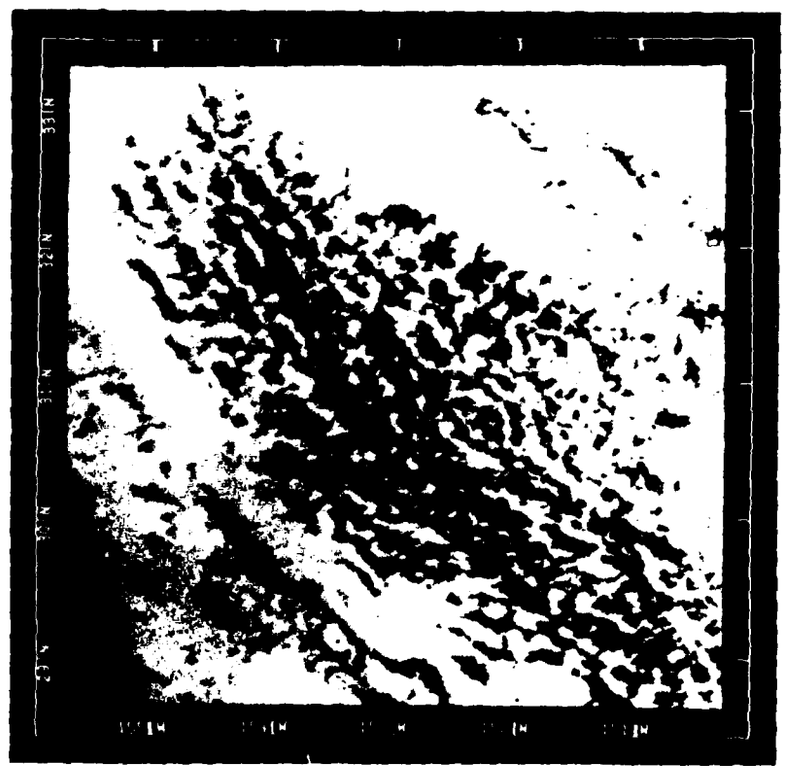

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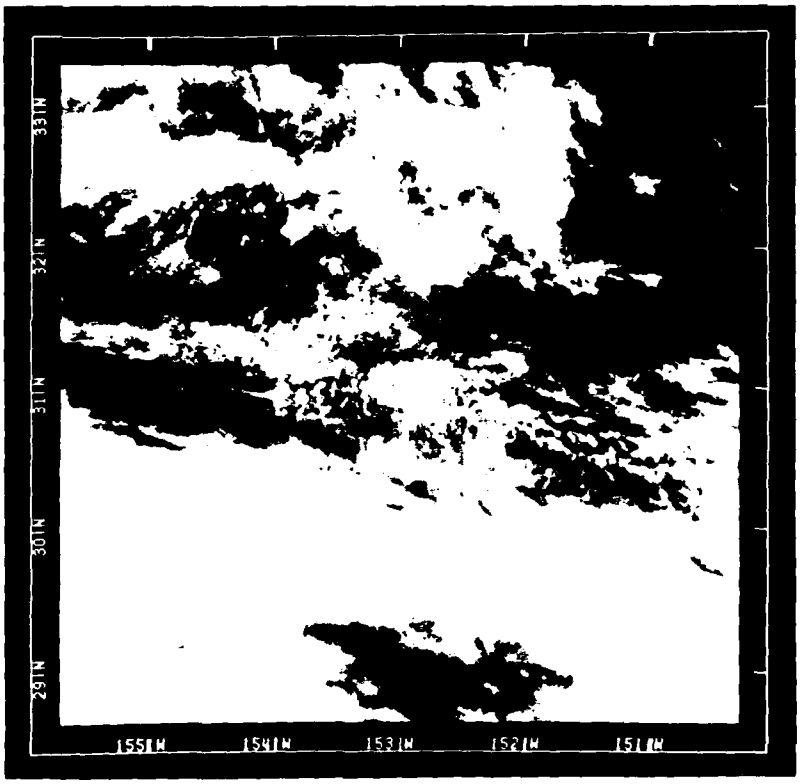

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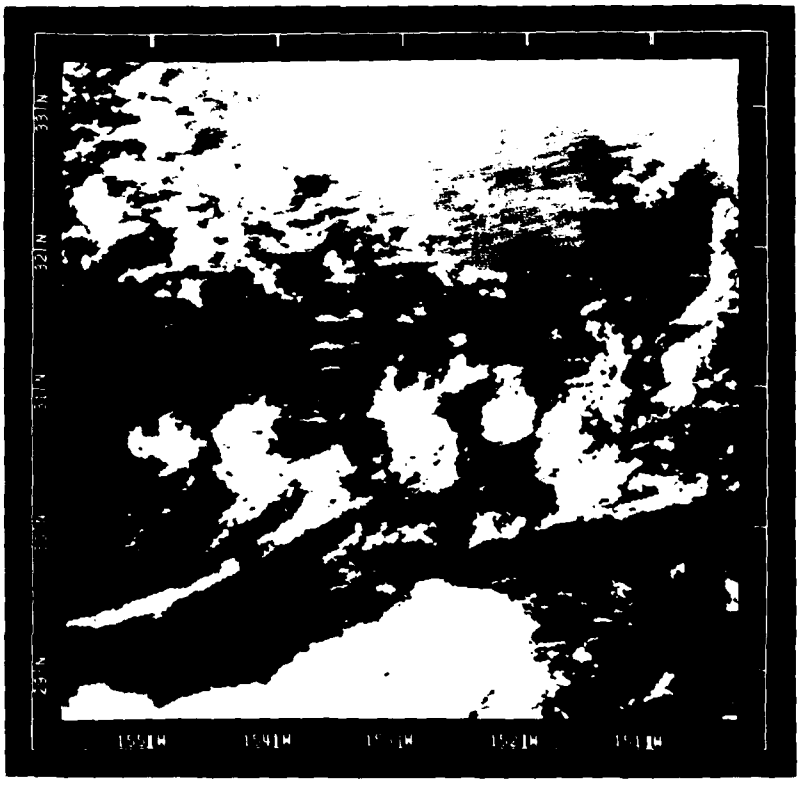

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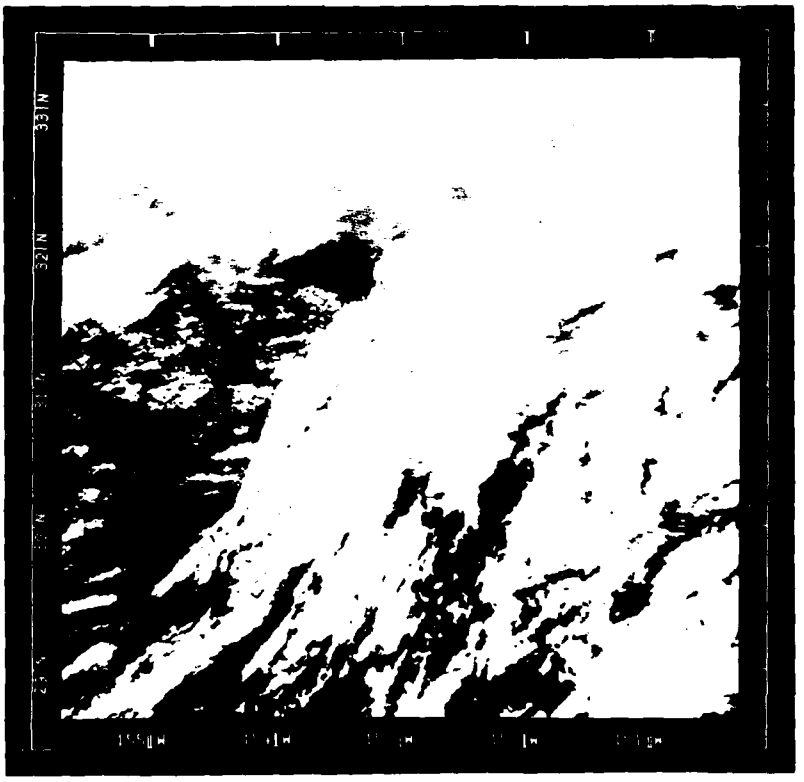

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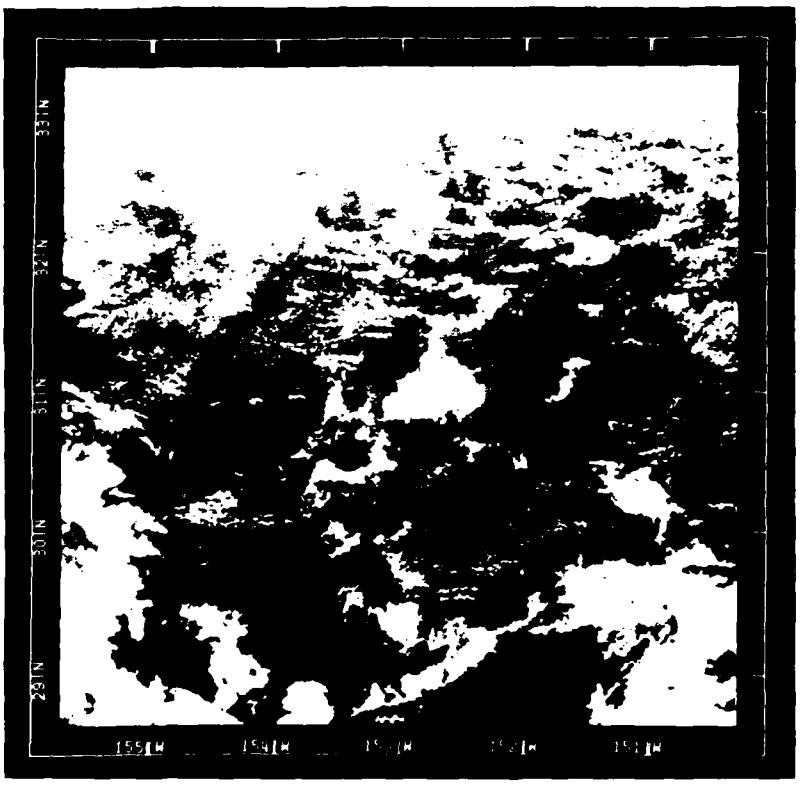

13 January, 1980 JD 013

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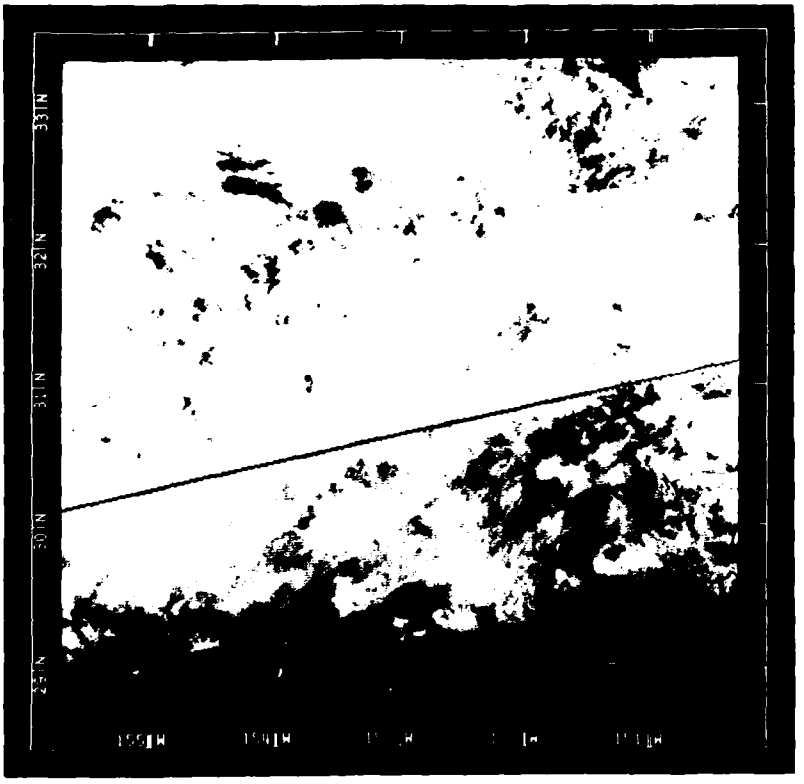

14 January, 1980 JD 014

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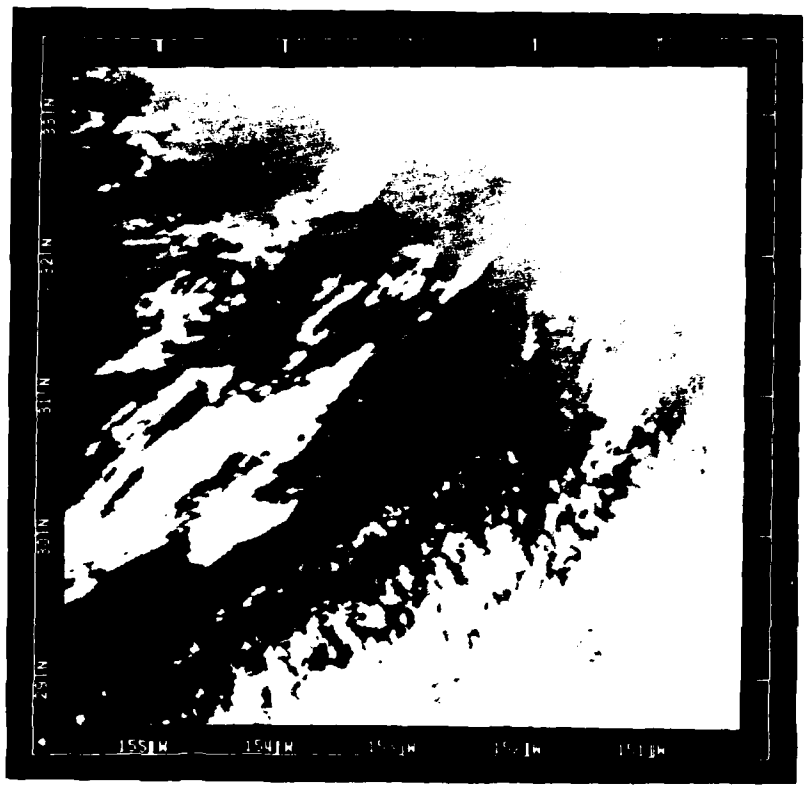

15 January, 1980 JD 015

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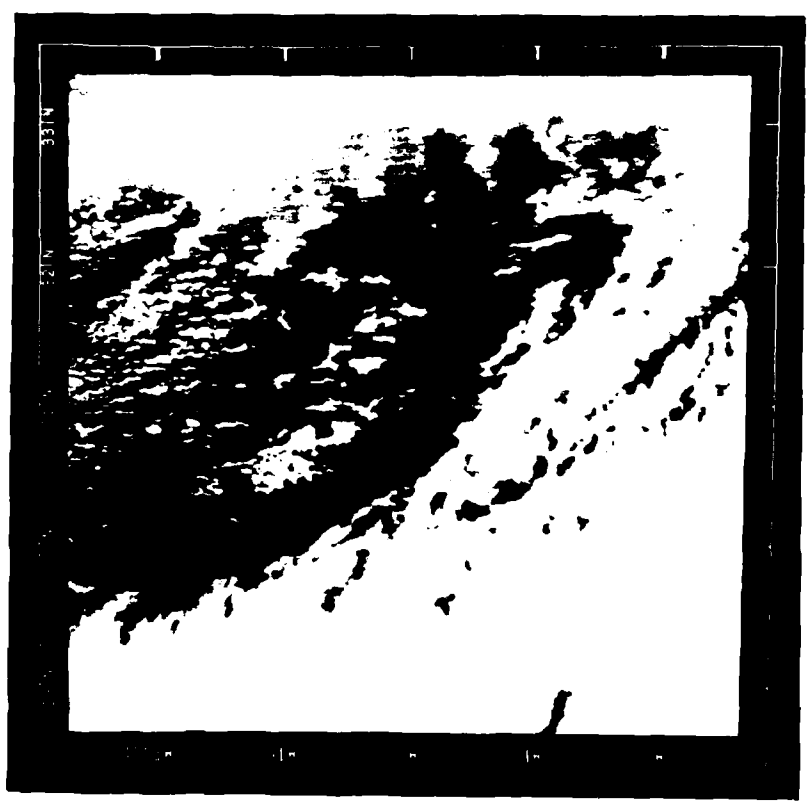

16 January, 1980 JD 016

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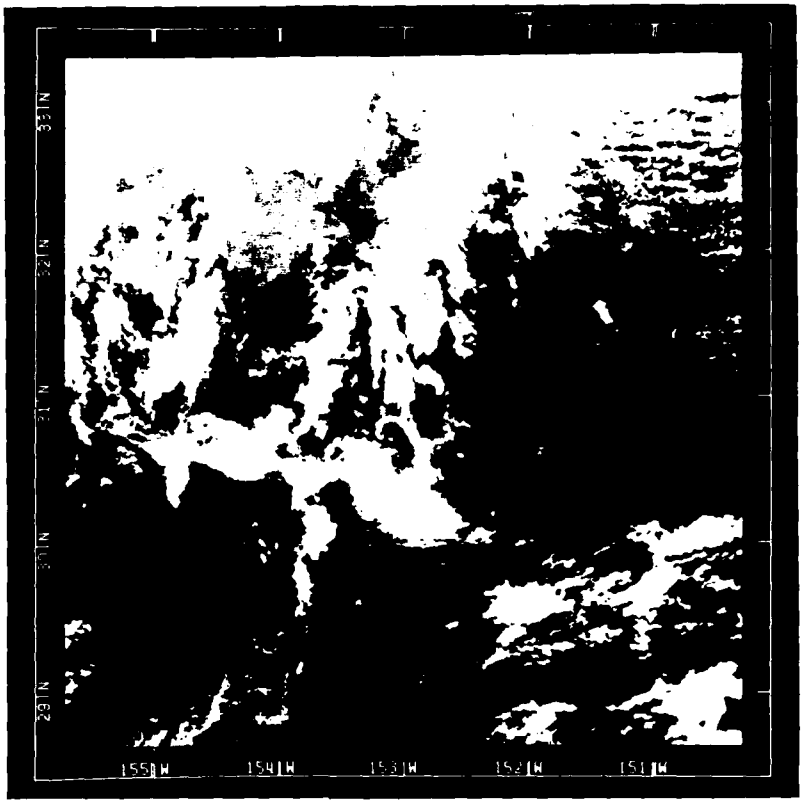

17 January, 1980 JD 017

B

18 January, 1980 JD 018

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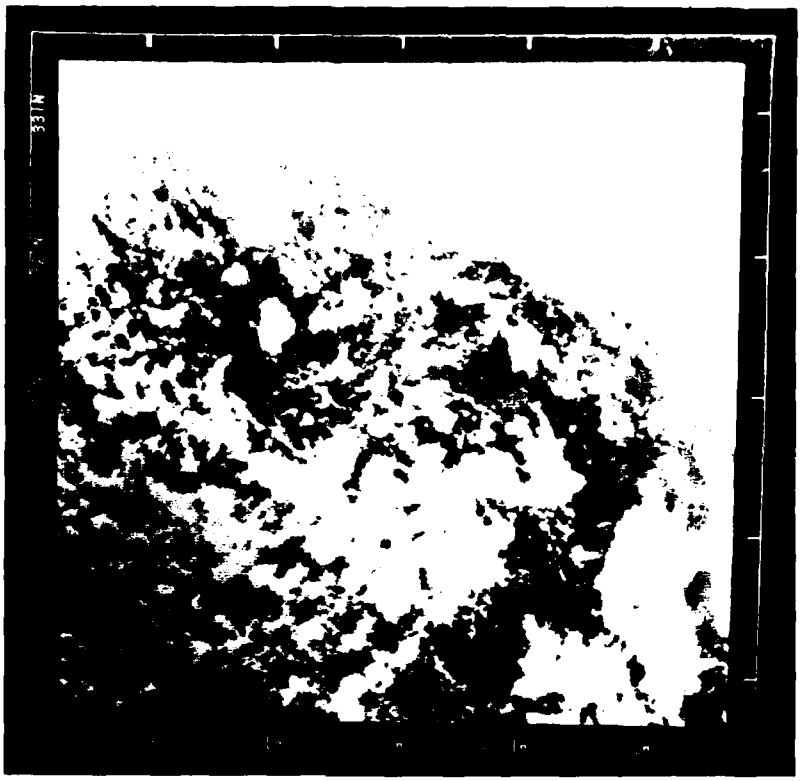

19 January, 1980 JD 019

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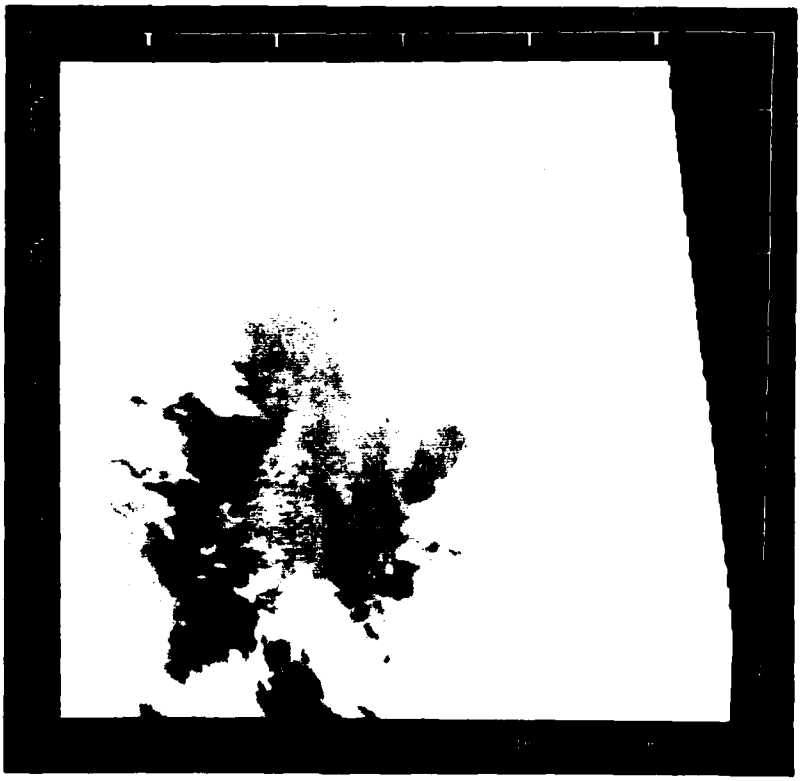

20 January, 1980 JD 020

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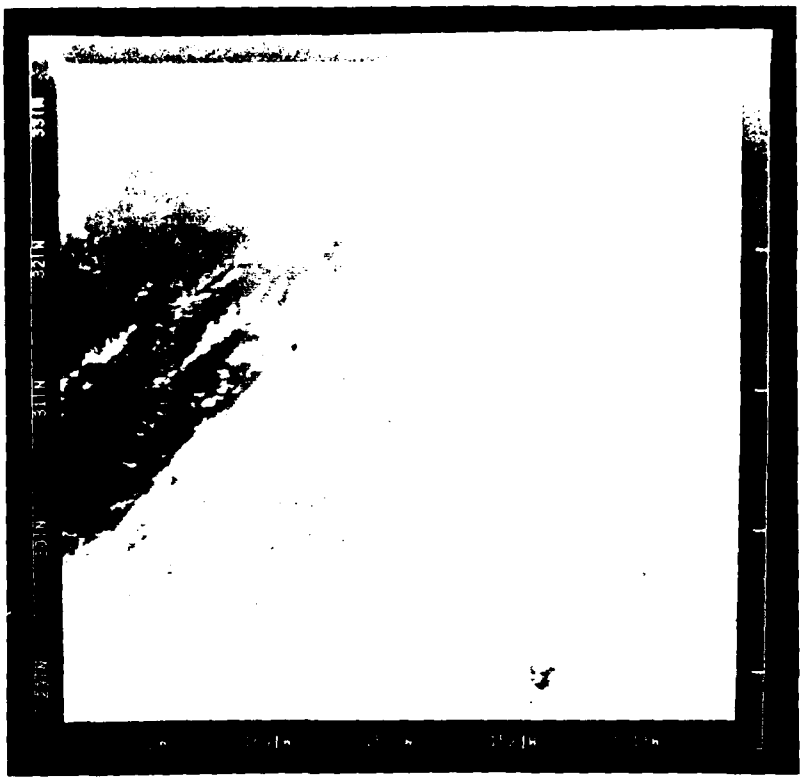

21 January, 1980 JD 021

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22 January, 1980 JD 022

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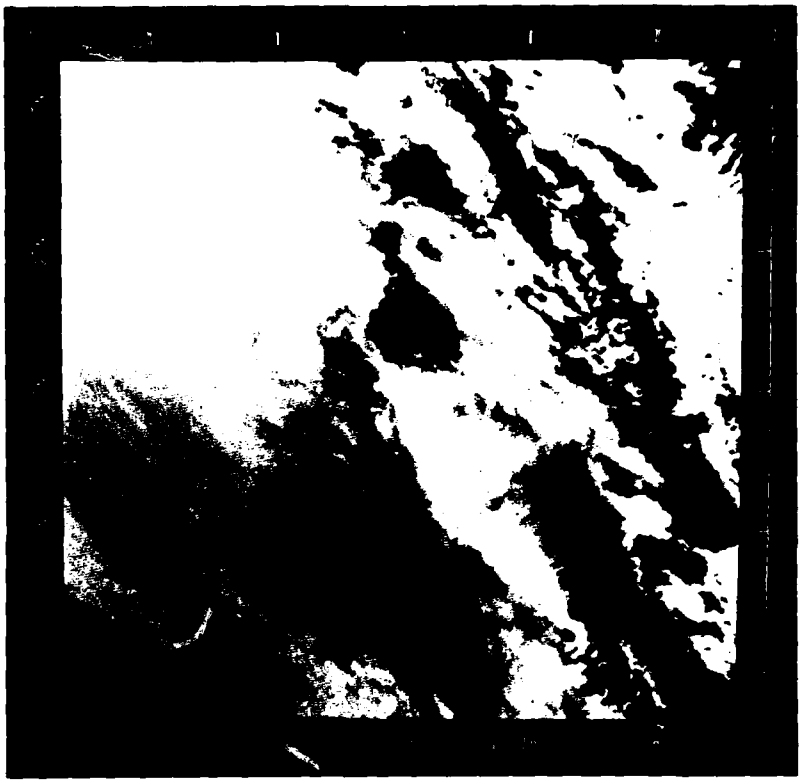
24 January, 1980 JD 024

B

25 January, 1980 JD 025

A



26 January, 1980 JD 026

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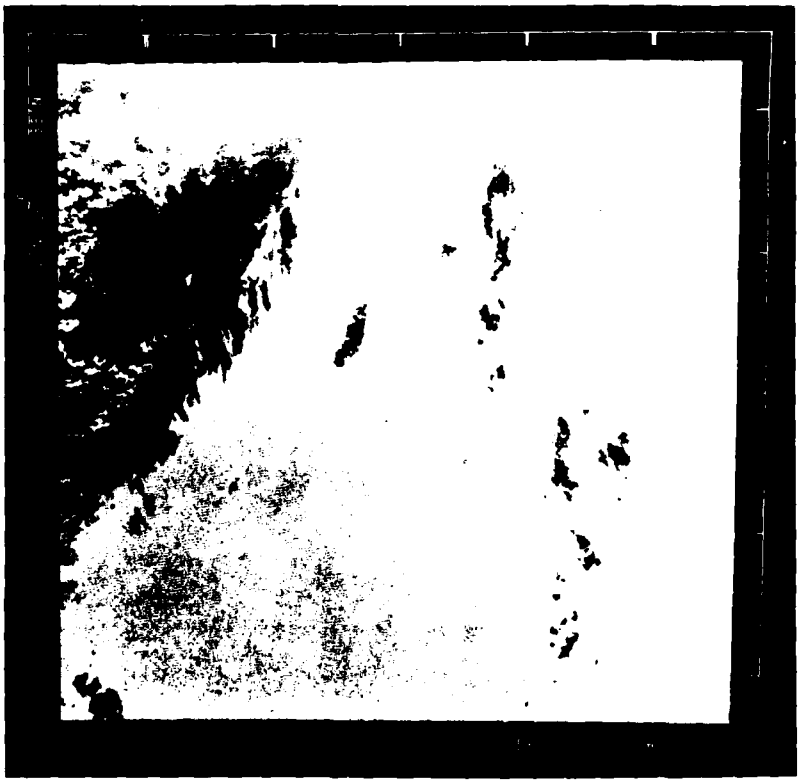

27 January, 1980 JD 027

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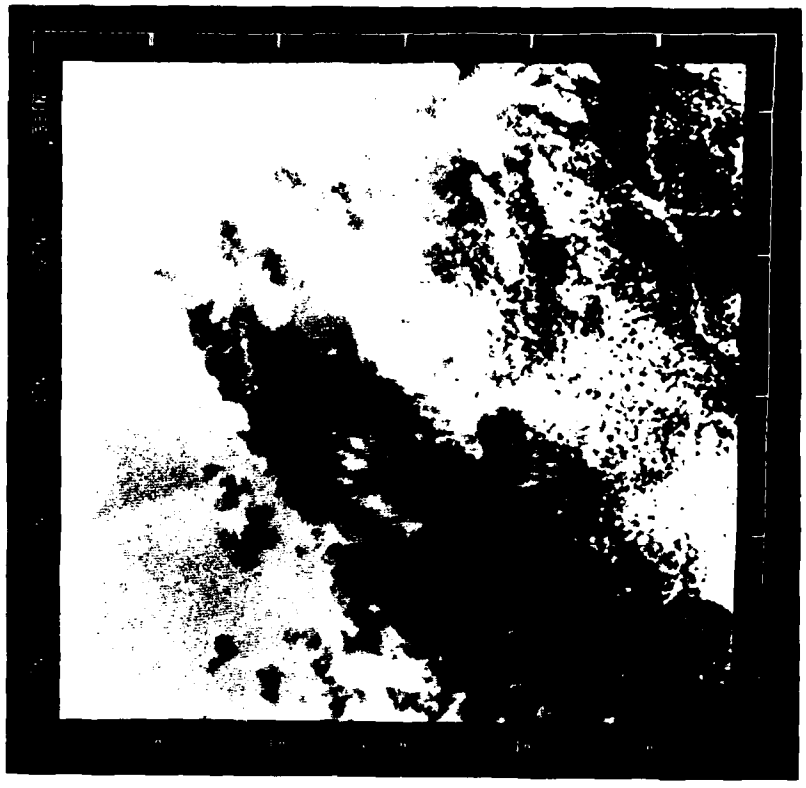

28 January, 1980 JD 028

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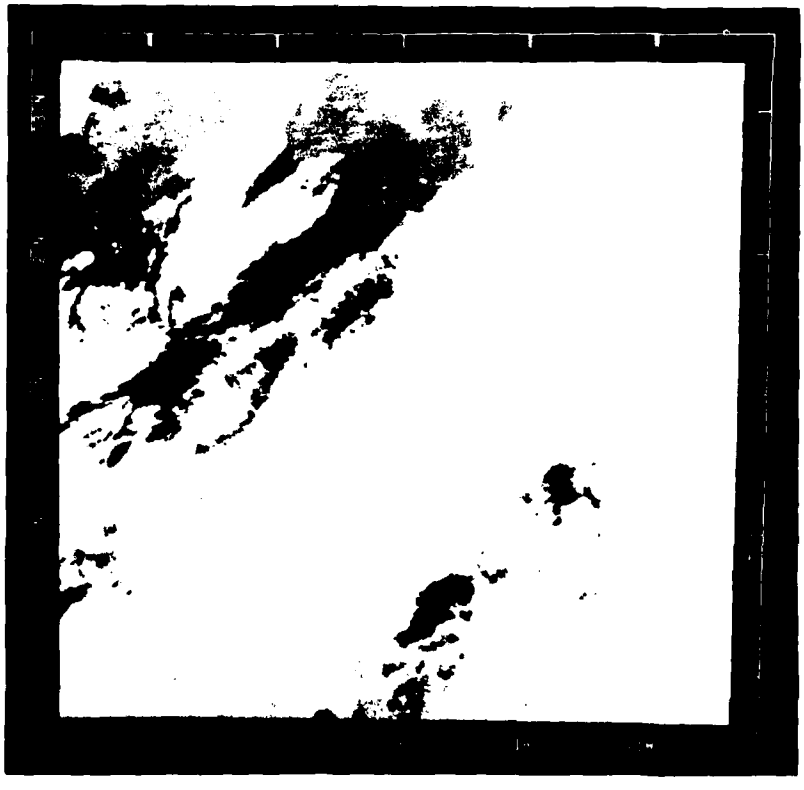

30 January, 1980 JD 030

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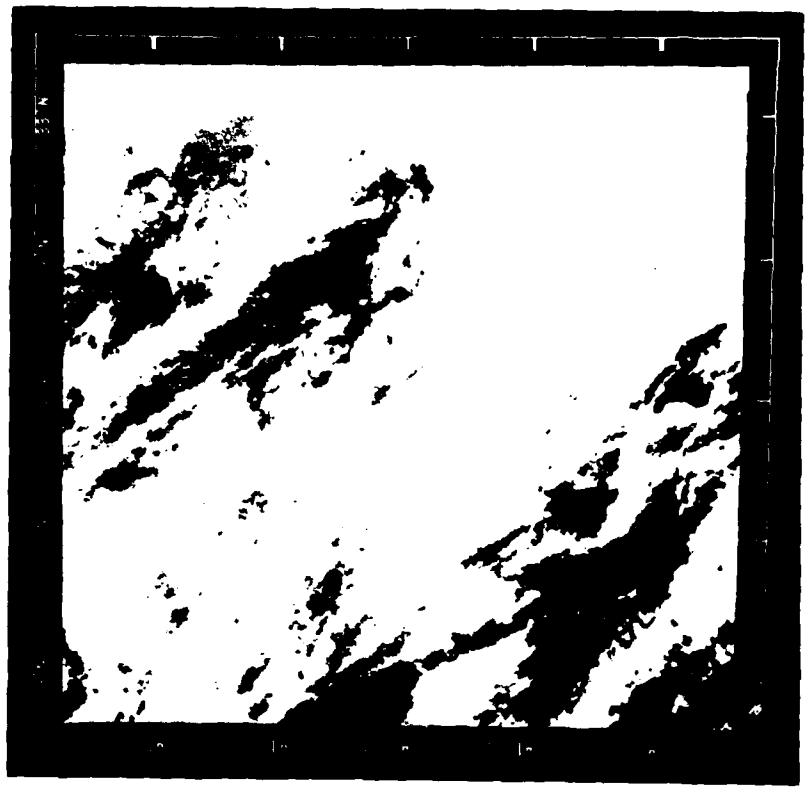

1 February, 1980 JD 032

B

8 February, 1980 JD 039

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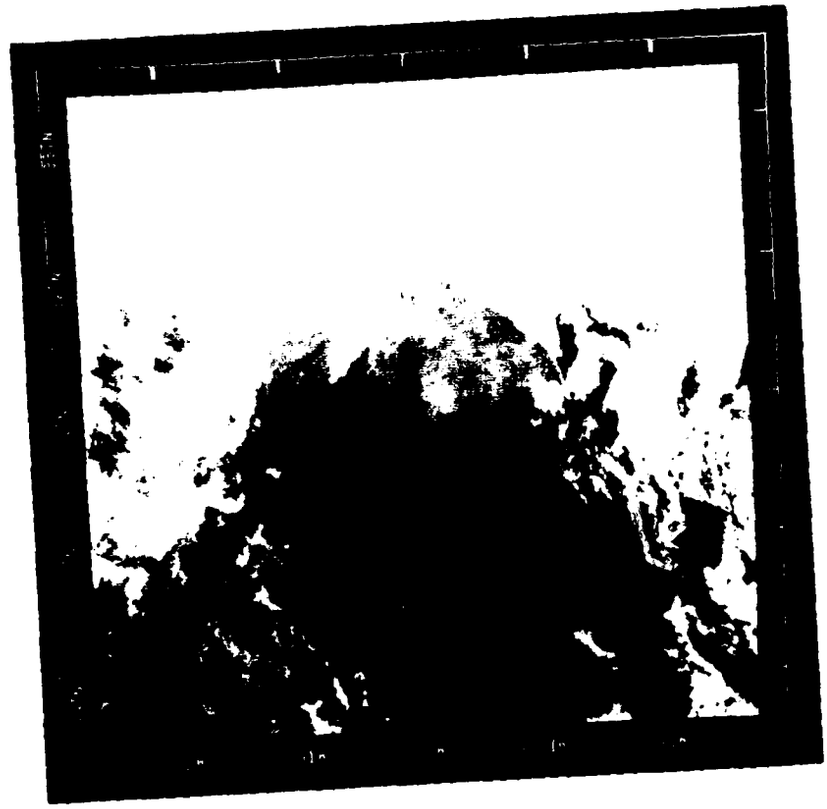

9 February, 1980 JD 040

B

13 February, 1980 JD 044

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14 February, 1980 JD 045

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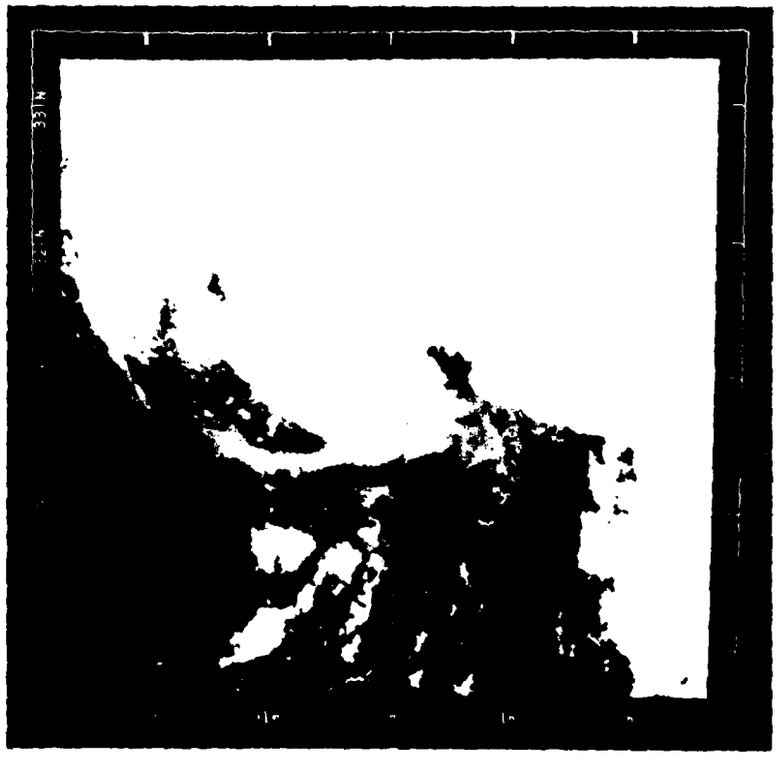

15 February, 1980 JD 046

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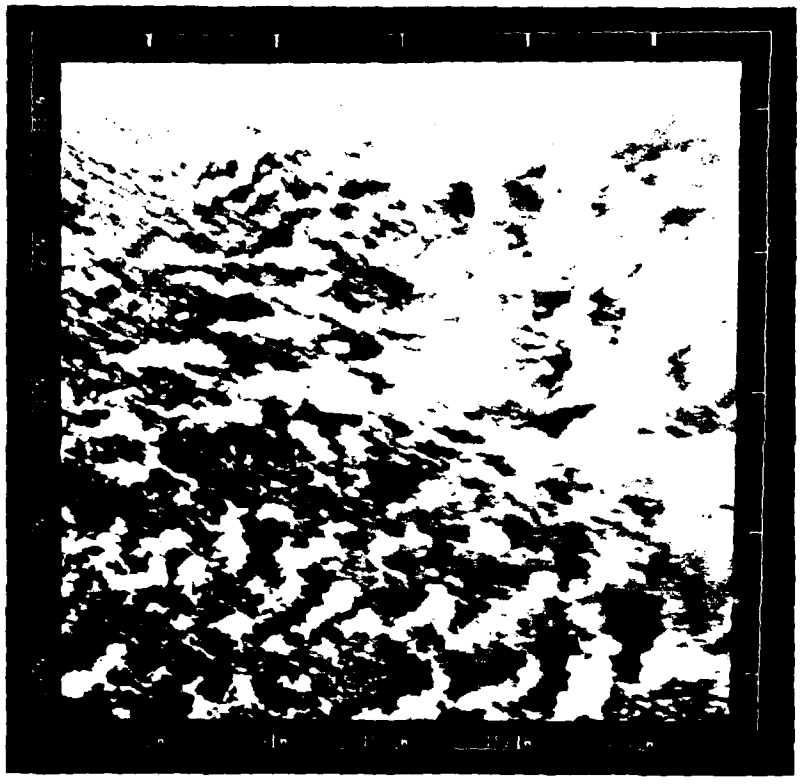
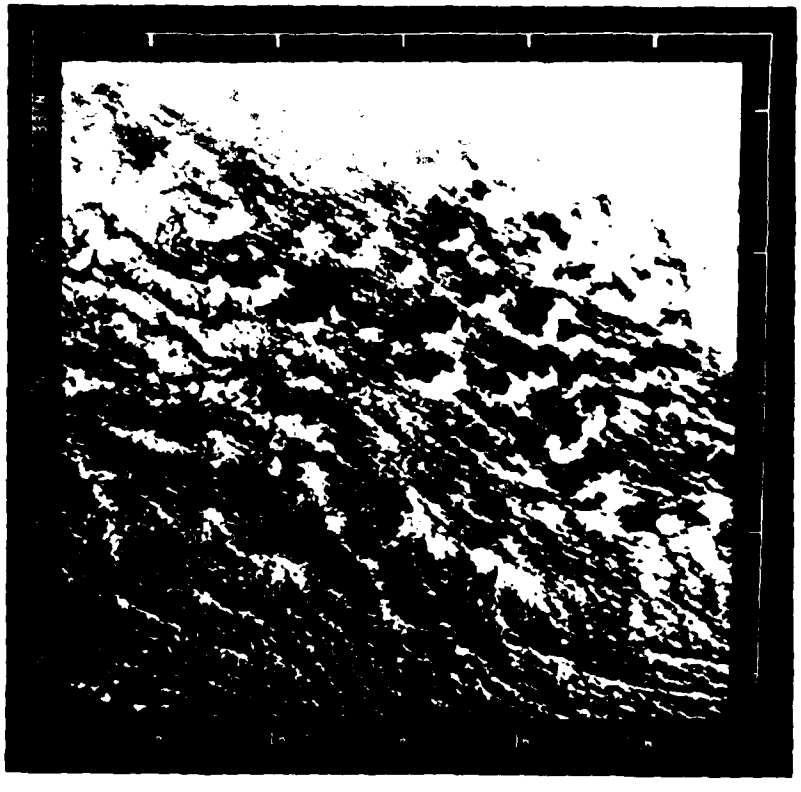


17 February, 1980 JD 048

B

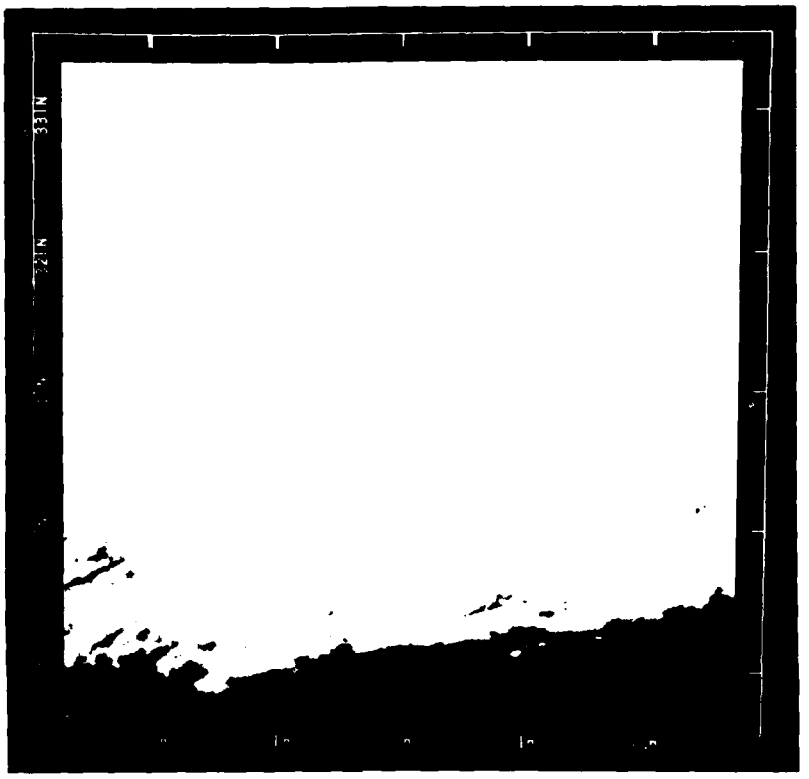


18 February, 1980 JD 049

A

19 February, 1980 JD 050

B



20 February, 1980 JD 051

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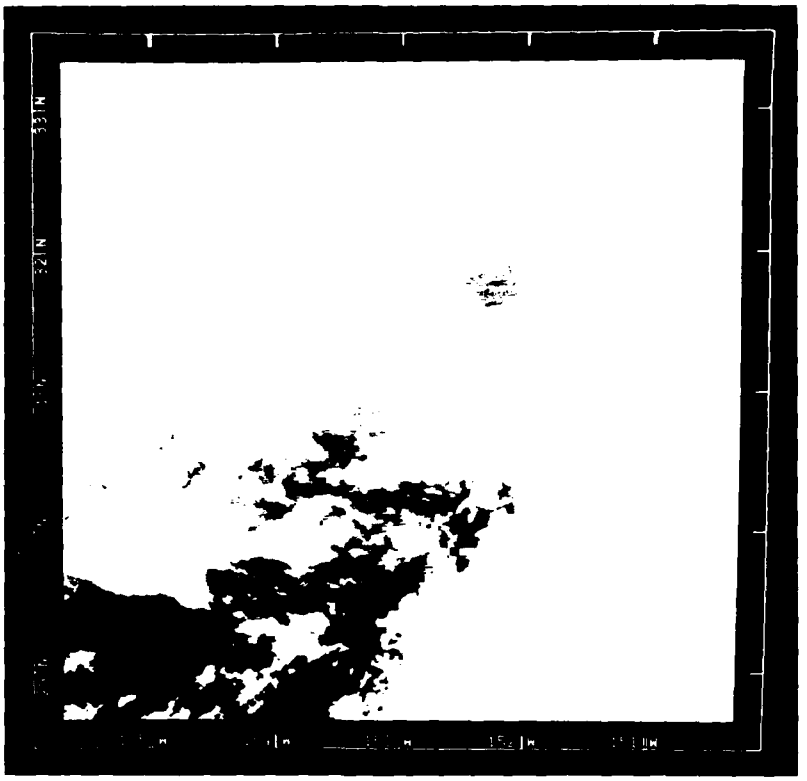

22 February, 1980 JD 053

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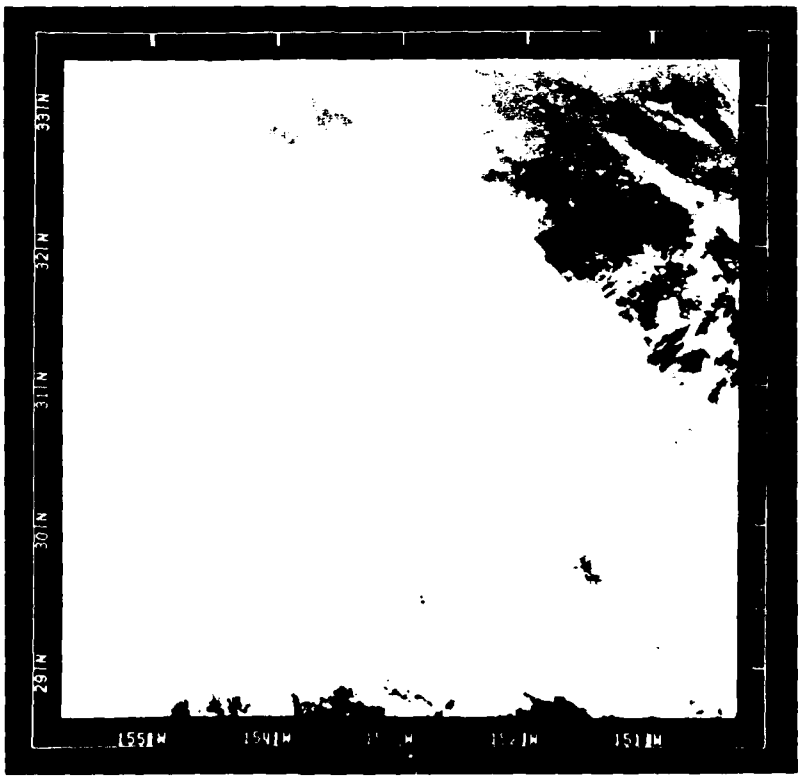

23 February, 1980 JD 054

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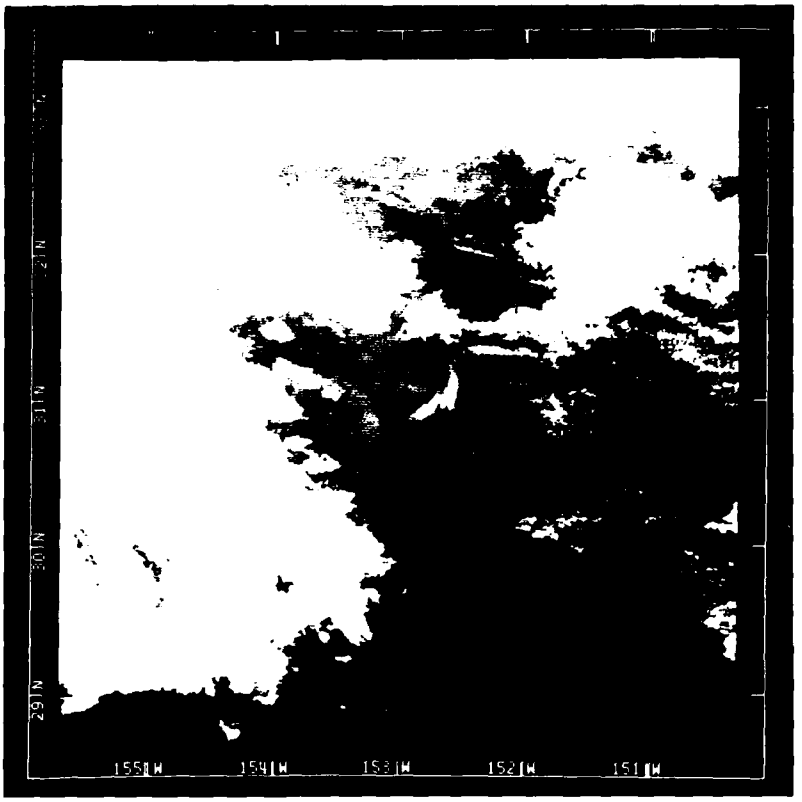

24 February, 1980 JD 055

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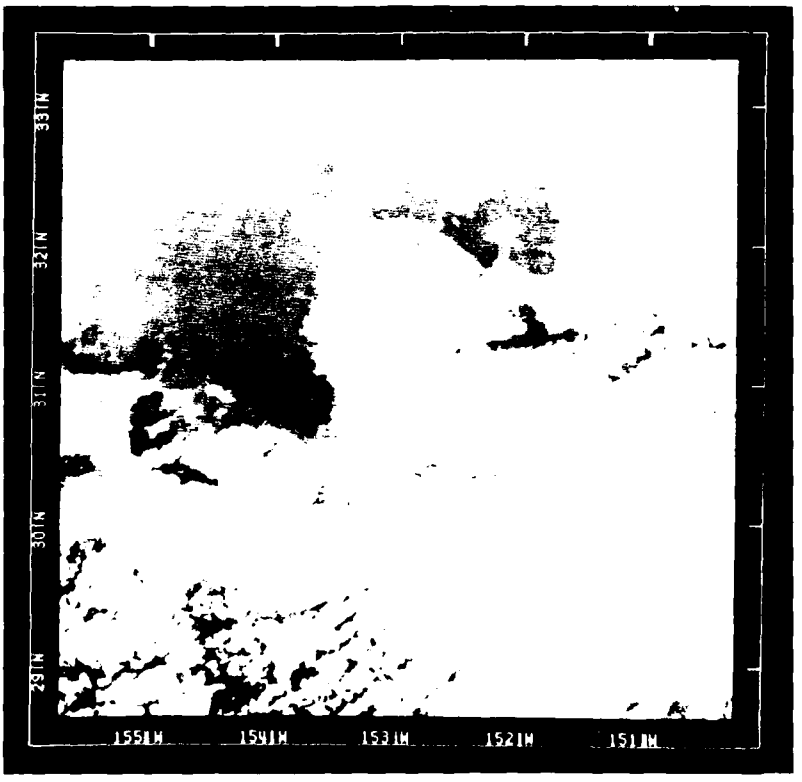

7 March, 1980 JD 067

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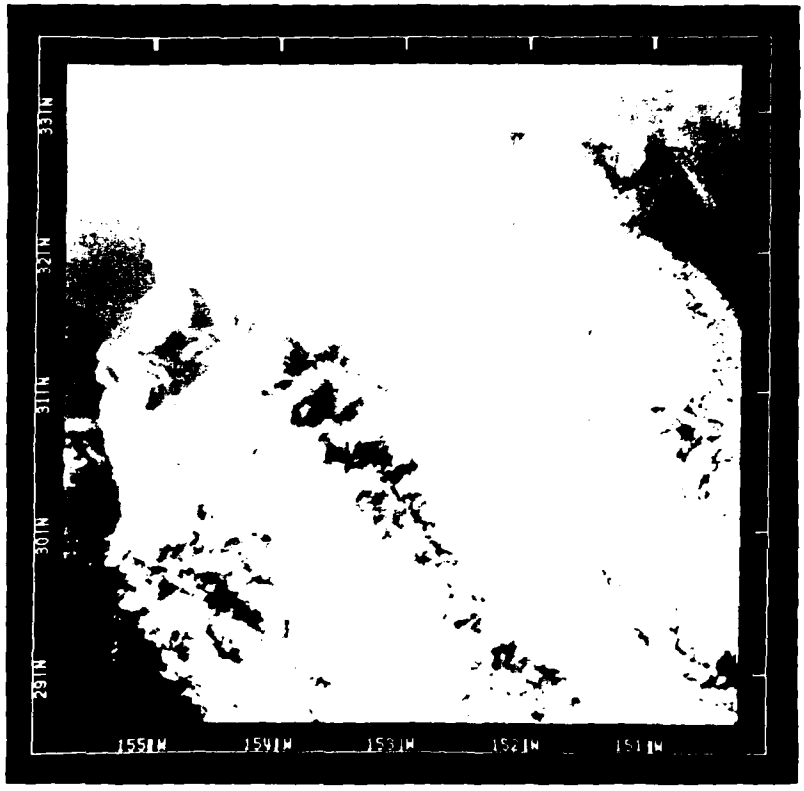

8 March, 1980 JD 068

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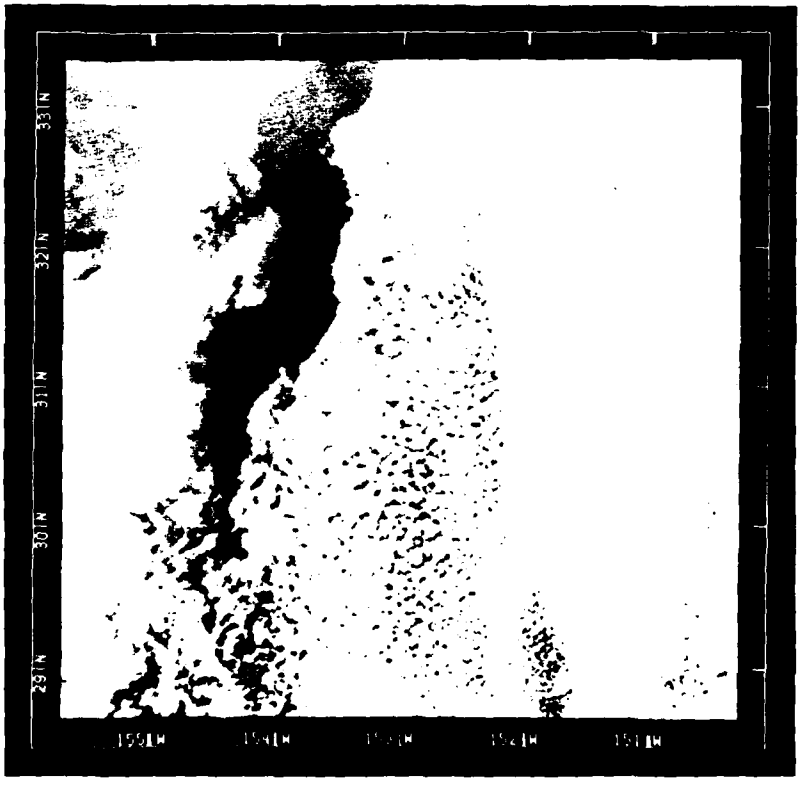

9 March, 1980 JD 069

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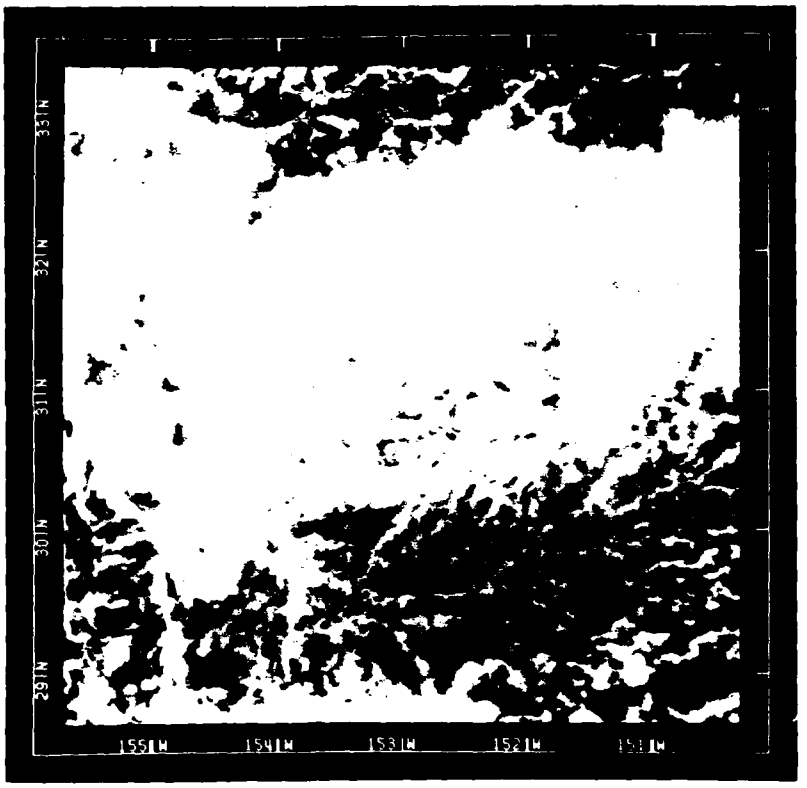

11 March, 1980 JD 071

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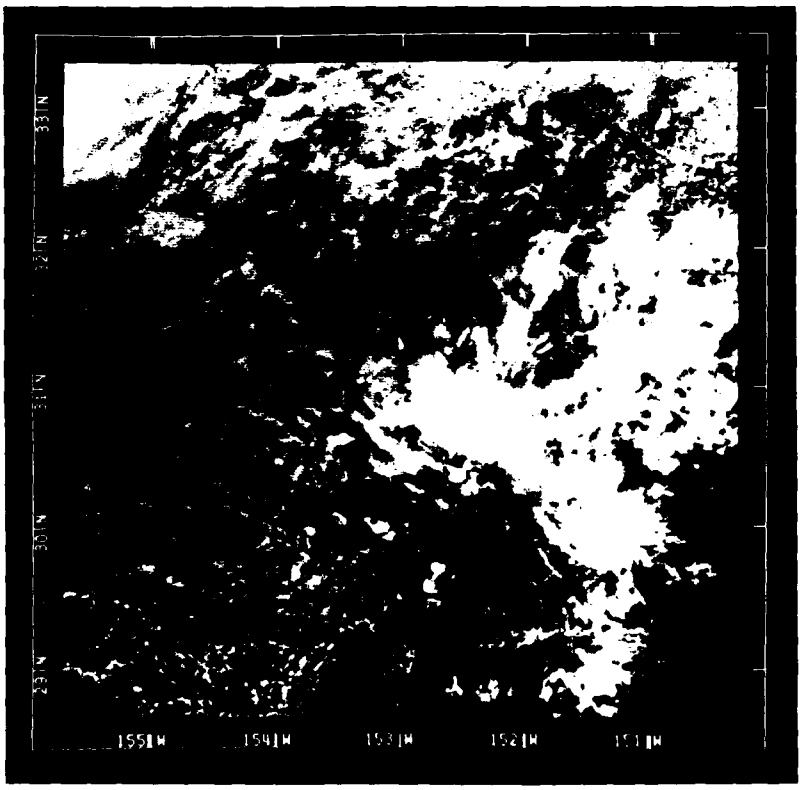

12 March, 1980 JD 072

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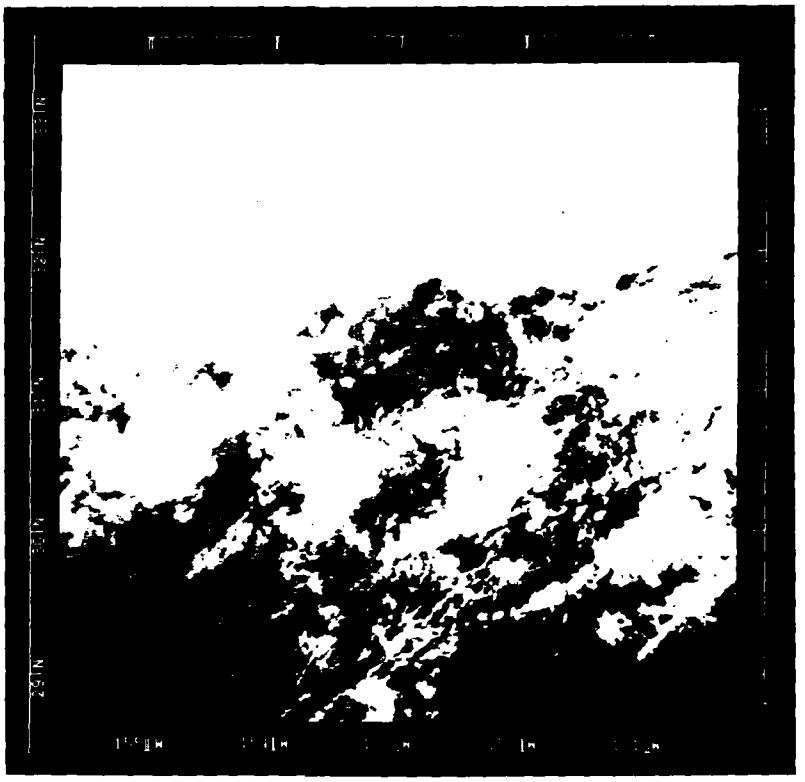

14 March, 1980 JD 074

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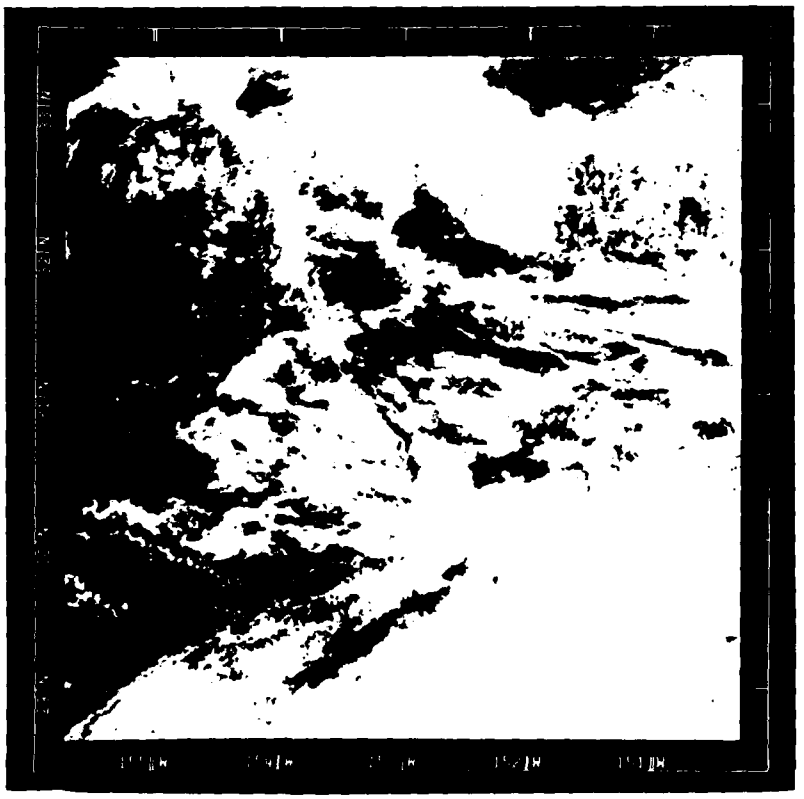

18 March, 1980 JD 078


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